

**MUD CREEK BASIN AND UPPER HUNTINGTON CREEK BASIN  
CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT  
(CHIA)**

For

SKYLINE MINE  
C/007/0005

WHITE OAK MINE  
C/007/0001

and

BLAZON MINE  
FOR/007/0021

In

CARBON, EMERY, AND SANPETE COUNTIES, UTAH

February 28, 2006



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## I. INTRODUCTION

The Skyline, White Oak, and Blazon mines are located in the northern Wasatch Plateau Coal Field, approximately 5 miles southwest of Scofield Reservoir and 25 miles west of the city of Price, Utah. Castle Valley, where the cities of Price and Huntington are located, lies east of the Wasatch Plateau, and farther east is the San Rafael Swell. The Sanpete valley is west of the Wasatch Plateau (Figure 1, Appendix A).

### Skyline

The Skyline Mine straddles the drainage divide between the upper Huntington Creek and Mud Creek basins. The Carbon - Emery County line follows this same divide. Though Skyline Mine has workings beneath both basins, the mine's only portals are in Eccles Canyon in the Mud Creek basin. Skyline's boundary stops at the Sanpete County line on the west.

The Skyline Mine has workings in three different seams, the Upper O'Connor Seam (Mine No. 1), the Lower O'Connor B Seam (Mine No. 2), and the Lower O'Connor A Seam (Mine No. 3). Construction of the Skyline Mine Facilities began in 1980, and the No. 3 Mine and No. 1 Mines began production in October 1981, and June 1982, respectively. Development of the #2 mine began in 1992. In addition to the mine offices, surface facilities include: a conveyor down Eccles Canyon, a loadout at the mouth of Eccles Canyon, a waste rock disposal site in U.P. Canyon near the town of Scofield, and a ventilation portal opened by breakout from the #3 mine into the South Fork of Eccles Canyon.

The Skyline Mine was idle from May 2004 to January 2005, after completing mining in the southwest portion of the mine. During that time, Canyon Fuel Company continued to pump water from the mine, ventilate it, and perform maintenance duties on the surface and underground. In January 2005 they began development mining in the North Lease area, and will begin longwall mining in the North Lease in early 2006.

### White Oak

The White Oak Mine was located east of, and adjacent to, the Skyline Mine. This mine was previously known as Valley Camp and the Belina Complex. In addition to the mine site, surface facilities included a loadout in Pleasant Valley, just south of Scofield, and an office building just across the highway from the loadout. Access to the reclaimed White Oak Mine site is through Whisky Canyon, a side canyon to Eccles Canyon. Approximately 22 % (700 acres) of the White Oak permit area lies within the Huntington Creek basin, and the remainder is in the Mud Creek basin.

Construction of the White Oak Mine facilities began in 1975. The White Oak Mine operated underground from 1979 through September 2001. Lodestar Energy, Inc. surface mined

much of the White Oak Mine portal area from November 2001 through April 2003. Lodestar went through bankruptcy proceedings during 2003 and 2004 and did not finish mining or reclaiming the portal area. The Division of Oil, Gas, and Mining (the Division) completed reclamation of the mine and loadout sites in late 2005 with money from the surety company and a settlement with the owners and controllers of Lodestar.

### Blazon

The Blazon #1 Mine was located just south of the town of Clear Creek. Construction on the Blazon #1 Mine began in July 1980, and the mine produced coal from March 1981 through January 1982. North American Equities forfeited the reclamation bond on the site, and the Division has subsequently reclaimed it.

### CHIA Objectives

This cumulative hydrologic impact assessment (CHIA) is a findings document involving an assessment of the cumulative impact of all anticipated coal-mining operations on the hydrologic balance within the Cumulative Impact Area (CIA). The CHIA is a determination of whether or not there will be material damage resulting from the cumulative effects of adjoining mines outside of individual mine permit boundaries. This report complies with federal legislation passed under the Surface Mining Control and Reclamation Act (SMCRA, Public Law 95-87) and subsequent Utah and federal regulatory programs under R645-301-729 and 30 CFR 784.14(f), respectively.

The objectives of a CHIA document are to:

1. Identify the Cumulative Impact Area (CIA). (Part II)
2. Describe the hydrologic system – including geology, identify hydrologic resources and uses. (Part III)
3. Document the baseline conditions of surface and ground water quality and quantity. (Part IV)
4. Identify Hydrologic Concerns (Identify which hydrologic resources are likely to be impacted and determine which parameters are important for predicting future impacts to those hydrologic systems). (Part V)
5. Identify relevant standards against which predicted impacts can be compared. (Part VI)
6. Estimate probable future impacts of mining activity with respect to the parameters identified above. (Part VII)

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7. Assess probable material damage. (Part VIII)
8. Make a statement of findings. (Part IX)

The original Belina (White Oak) Mine CHIA prepared by Engineering-Science (1984) and the Huntington Creek Basin CHIA prepared by Simons, Li, and Associates, Inc. (1984), for the U. S. Office of Surface Mining (OSM), provided much of the basic information used in this CHIA. The White Oak and Skyline Mine Reclamation Plans (MRP) have also been used. The original Technical Analysis (TA) for the Skyline Mine permit includes information similar to that required for a CHIA, but a complete CHIA was apparently not prepared at the time the original permit was approved in 1980.

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## II. CUMULATIVE IMPACT AREA (CIA)

Figure 2 (Appendix A) shows the boundaries of the Cumulative Impact Area (CIA). The Office of Surface Mining (OSM) defines the CIA as “an area where impacts from the proposed operation, in combination with other existing and anticipated operations may cause material damage.” The Division determines the CIA boundaries based on existing mining activities, anticipated mining activities, knowledge of surface and ground water resources, and anticipated impacts of mining on those water resources.

The CIA boundary was last revised in November 2002. The rationale for defining the CIA boundary is as follows:

On the west, the Gooseberry Fault runs north south, and is believed to form a barrier to groundwater flow. This would include the area between the west edge of the Huntington Creek drainage and Gooseberry Creek in the CIA. To also include springs along the fault escarpment, the boundary was extended west to Gooseberry Creek. Similarly, the Pleasant Valley Fault runs north south along the Mud Creek valley and is believed to form a boundary to groundwater flow. The Blazon, White Oak, and Skyline Mines (including the North Lease added in 2005, and possible future Flat Canyon Lease) lie between these two faults. Granger Ridge and Scofield Reservoir bound the northern end and the southern boundary was extended in 2002 to include Electric Lake. The CIA includes about 54,936 acres with about 28,034 acres in the Mud Creek drainage, about 26,002 acres in the Huntington Creek drainage, and about 900 acres in the Gooseberry Creek drainage.

The CIA encompasses all of the Mud Creek basin; from Scofield Reservoir on the north, to the southern end at the Carbon/Emery County Line. This basin includes the ephemeral drainages on the east side of Pleasant Valley, one of which is U.P. Canyon where Skyline's waste rock disposal site is located. The north end of the Mud Creek drainage includes the Woods Canyon and Winter Quarters Canyon drainages. The White Oak Mine lies mostly in the Mud Creek Basin, and the Blazon Mine is included entirely within the Mud Creek drainage area. The Blazon Mine has been reclaimed, but remains within the Division's jurisdiction.

The mountain ridge on the west side of the Mud Creek drainage is also the east side of the Huntington Creek drainage. That ridge, or divide, forms part of the boundary between Carbon and Emery Counties. The north end of the CIA boundary in the Mud Creek drainage is Granger Ridge. Granger Ridge connects the common ridge between Mud Creek & Huntington Creek, to Scofield Reservoir.

Scofield Reservoir is included in the CIA because Skyline mine-water discharges flow down Eccles Creek into Mud Creek, and then into Scofield Reservoir. Mud Creek is known to contribute 16 % of the water inflow to the reservoir, Fish Creek supplies approximately 75% (Waddell and others, 1983b, p. 43) and Pondtown, Lost/Dry Valley, and Miller Canyon Creeks

account for the remaining 9%. Though Mud Creek supplies just 16% of the water to Scofield Reservoir, it contributes 18% of the total nitrogen and 24% of the total phosphorous inflows (Waddell et al., 1983a). The total phosphorous in Scofield Reservoir is of concern to the Utah Division of Water Quality, and they have set the Total Maximum Daily Load (TMDL) Target Load of 4,842 kg/yr (29 lb/day). The historical data suggest that the Mud Creek drainage has nutrient-rich soils, which are fairly easily eroded, and carried down stream. However, increased flows from the Skyline mine-water discharge have not appreciably increased the amount of total phosphorous in Mud Creek through increased stream bank erosion (measured at MC-3; see Figure 12, Appendix A, EarthFax 2002, 2003, 2004). The Price River, which is used for irrigation in Castle Valley and provides the municipal water supply for the city of Price, flows from the reservoir. The increased flows (March 1999-Present) have increased the water volume in the reservoir and have provided considerably more water to the Price River drainage than natural runoff would have. Other than increased flows, no other hydrologic impacts have been noted downstream of Scofield Reservoir.

The CIA also encompasses all of the Huntington Creek drainage above the mouth of Valentines Gulch. The area immediately below Electric Lake dam, down to North Hughes Canyon, includes the Valentine Fault which runs through Valentines Gulch and continues north into the area of the CIA where mining has occurred. The CIA includes Electric Lake itself, which covers from 100 to 450 acres, depending on water level, and contains 31,500 acre-ft of active annual storage. The lake is a contributor to groundwater in the CIA. Roughly half of the Skyline Mine permit area lies within the Huntington Creek drainage. Drainages on the west side of Huntington Canyon that are part of the CIA include Bear Canyon, Little Eccles Canyon, Boulger Canyon, Flat Canyon, Swens Canyon, Little Swens Canyon, Brooks Canyon, and Upper Huntington Creek.

Electric Lake became a part of the CIA in November 2002 because records provided by PacifiCorp (owner and operator of the Lake) indicated a marked decline in storage volumes beginning in July 2001; the same time Skyline Mine had a significant increase in mine-water inflows. These records, and claims by PacifiCorp that the two events were related, prompted the Division to closely study all reports related to the mine in-flows and Electric Lake water losses. In September 2001, Skyline Mine developed a well and began pumping water into Electric Lake. Although not considered mine-water discharge because it is not drawing water directly from the mine workings, Well JC-1 pumped an average of approximately 3,000 gpm into Electric Lake from September 2001 through September 2004 (~400 acre-ft/month). Starting in July 2003, another well (JC-3) started pumping mine-water discharge water into Electric Lake. JC-3 pumped through July 2004, at an average of 2,550 gpm (~340 acre-ft/mo) of mine-water discharge to Electric Lake, at which time it encountered both mechanical and water quality problems and was shutdown. According to Storage Volume records provided by PacifiCorp (HAL 2005, PacifiCorp 2003, 2004), the water provided to Electric Lake from the JC wells (~740 acre-ft/month at highest) has had little effect on the volume of water stored in the lake. JC-1 continues to consistently pump approximately 4,000 gpm (530 ac-ft/mo) into Electric Lake.

### **III. HYDROLOGIC SYSTEM**

The CIA is located in both the Mud Creek and upper Huntington Creek basins, which are the headwater basins of the Price and San Rafael Rivers, respectively. The Price River flows generally southeast and passes through the city of Price. Huntington Creek flows generally east. It emerges from the Wasatch Plateau near the town of Huntington and joins with Cottonwood and Ferron Creeks on the east side of Castle Valley to form the San Rafael River. The Price and San Rafael Rivers are tributaries to the Green River, which in turn is tributary to the Colorado River.

Precipitation on the Wasatch Plateau varies from 40 inches at higher elevations to less than 10 inches at lower elevations and more than 30 inches per year on the higher ridges and in the upper Huntington Creek basin (Coastal, 1993; Simons, Li, and Associates, 1984). Seventy to eighty-percent of the total precipitation falls as snow between October and April. Skyline Mine has a weather reporting station, which averages between 22 and 26 inches of precipitation per year. Actual and potential evapotranspiration rates are roughly equal (less than 18 inches per year) in the upper elevations of the Wasatch Plateau (Waddell and others, 1983b). Probably less than 5% of the precipitation recharges the ground water system (Price and Arnow, 1979). The Wasatch Plateau is classified as semiarid to sub-humid.

Vegetation varies from Sagebrush/Grass communities at lower elevations to Spruce/Fir/Aspen and Mountain Meadow communities at higher elevations. Other vegetative communities include Mountain Brush, Sagebrush, Ponderosa, and Riparian (Simons, Li, and Associates, 1984). These communities are generally used for wildlife habitat and livestock grazing. Even though slopes are steep, there is good vegetative cover, and soils with high organic content are well developed, providing an adequate medium for ground water recharge (Coastal, 1993, p. PHC2-5).

#### **Surface Water**

##### Mud Creek Drainage

Mud Creek basin is an asymmetric watershed. Watersheds on the dominant west flank contain perennial and ephemeral streams that flow eastward to Mud Creek through straight, deeply incised canyons. Small, ephemeral watersheds drain to Mud Creek from the east flank of the basin (Fig. 5, Appendix A).

Mud Creek flows north through Pleasant Valley to Scofield Reservoir and normally constitutes around 16% of the annual flow to that reservoir (Valley Camp, 1993, p. 40). Since March 1999, inflows to Skyline Mine were pumped to abandoned underground workings and, after appropriate settling, pumped to Eccles Creek, a tributary to Mud Creek. Skyline measures and reports these discharges to Eccles Creek quarterly as CS-12 (Mine 3 discharge) and CS-14

(Mine 1 discharge). Until March 1999, the combined discharge to Eccles Creek never exceeded 795 gpm, and averaged just 285 gpm. Combined mine-water discharges to Eccles Creek have been recorded continuously and reported monthly since August 16, 2001 (data available at <https://fs.ogm.utah.gov/pub/MINES/Coal/007/C0070005/DischargeInfo/Mine-James-%20Discharge.xls>). Since August 2001, the average monthly discharge has varied from 860 gpm to 9,846 gpm, with an average discharge of 5,666 gpm. Since January 2004, Skyline has allowed some abandoned workings in the southwest portion of the mine to flood. The allowed flooding of mine workings combined with decreased mine inflows has reduced the discharge to Eccles Creek from a peak monthly average of 9,846 gpm to a monthly average of 4,596 gpm since. The mine workings in the southwest portion of the mine were completely flooded in September 2004, and with the water in the mine workings at a static level, it will be possible to accurately measure mine inflows. It will also be possible to measure the effects of increased head (if any) on the inflows.

The increased flow in Eccles Creek peaked at approximately 10 times the average annual amount and increased flow in Mud Creek to about 1.2 times the average pre-1999 flow. At the same time, the peak monthly flows were only about 13% of spring runoff rates. An ongoing study (EarthFax 2002, 2003, 2004) to analyze the impacts to Eccles and Mud creeks indicated that the streams were well armored and that so far, the increased flows have affected them very little. Mine water discharge decreased to approximately 3,500 gpm in October 2004 (~ 2,500 from SW portion of mine, ~ 600 from 14L/15L/16L, and ~350 from Mine #3). Canyon Fuel estimated that it would continue at that rate for another 5 years, but it has crept up slightly due to discharges of stored water from Mine 3 as they develop the North Lease. The discharge averaged 4,169 gpm from October 1, 2004 to December 31, 2005.

### Upper Huntington Creek

Ephemeral and perennial streams drain the upper Huntington Creek Basin (approximately 20,000 acres; 18,000 acres in the CIA), and flow into Electric Lake, which is owned and operated by PacifiCorp (formerly Utah Power and Light Company). PacifiCorp also holds a significant portion of the water rights in the Huntington Creek basin, which they use to cool their coal-fired electric generating plant located downstream along Huntington Creek. Electric Lake has regulated the discharge of upper Huntington Creek since its construction in 1973.

Beginning in August 2001, PacifiCorp began noticing that the water level in Electric Lake was dropping faster than they were discharging it at the dam. The change in lake response is clearly seen in Figure 13, based on data that PacifiCorp provided. PacifiCorp has monitored the water levels in the lake and the amount of water being released from the dam on a monthly basis. Lake inflows were not measured, but estimated or 'imputed' by subtracting the amount of water released at the dam from the change in water volume of the lake. Over time these imputed numbers showed a fairly consistent performance of the reservoir. In August 2001, the imputed inflow numbers were consistently negative, implying that the lake was losing water at a significant rate. Traditionally, reservoirs such as Electric Lake have no need to collect accurate inflow numbers; as long as the reservoir holds sufficient water for uses downstream, there is no need to spend time and money investigating the exact nature of all inflows and outflows.

Standard water-balance budgets for reservoirs generally assume both a groundwater inflow and groundwater outflow component (i.e. communication with bedrock, flow into faults, saturation of alluvial sediments, etc). However, because of the changed response in lake function, PacifiCorp began measuring the inflow into Electric Lake in July 2002 with a flume located on Huntington Creek above the Lake. The flume was recalibrated in June of 2003 and continues to collect flow data when not inundated. Because the lake level was rising in 2004, PacifiCorp installed a second flume further upstream, but still below Boulger Creek in May of 2004. With these two flumes, measurement of inflow coming from Upper Huntington Creek has been continuous, with the exception of periods when the flumes were either washed-out or inundated. Side flows that occur during spring runoff and other high-flow periods have also been measured at least twice per year, and estimated as a percentage of total flow during months when not directly measured. Figure 14 illustrates both the calculated and measured inflows for Electric Lake (HAL).

Intuitively, it may appear as though the increased losses noted at Electric Lake are associated with the increased mine inflows experienced at the Skyline Mine. However, despite the efforts of all parties, studies supplied by the Skyline Mine and PacifiCorp do not *conclusively* prove or disprove a direct connection. These studies will be discussed in more detail in Section VII of this CHIA.

#### Surface Water Usage

Hansen, Allen, and Luce, Inc. conducted a survey of water rights for Valley Camp of Utah in 1990. The survey covered most of the CIA. One hundred and ninety four surface water rights were found, 106 for stock watering, 25 for irrigation, 55 undeclared, and the remaining 8 for other uses. Skyline Mine conducted an updated survey of the water rights in their permit area in 2002, in conjunction with the addition of the Winter Quarters/North Lease. Most streams in the CIA have water rights filed on them.

Figure 15 graphically illustrates the Operation of Electric Lake compared with the amount of available water based on the Surface Water Supply Index for the San Rafael drainage basin for the 1983 – 2002 period. The graph generally reflects that when sufficient water is available, both Electric Lake Storage and Discharge are high. When water availability is low, storage is correspondingly lower. An interesting comparison is the 1978-79 period to the 2001-02 period. In 1978, the average storage was 18,600 acre-ft while total discharge was 9,375 acre-ft. In 2001, the average storage was 16,397 acre-ft while discharge was 14,945 acre-ft. Surface Water Supply Index information is not available for 1979, however with total discharge being only approximately 50 percent of the average storage volume in 1978, the storage volume rose in 1979. The opposite effect was noted in 2001-02 when total discharge was 91 percent of the average storage volume in 2001. This was also compounded by the drought conditions experienced in the area since 1998, as illustrated by the Surface Water Supply index information. However, some of the effects of drought were negated with approximately 25 percent (4,480 acre-ft) of the water being pumped into Electric Lake from the JC-1 well.

## **Ground Water**

Ground water is found principally in two configurations within the CIA: numerous small, localized perched systems related to discontinuous sandstone lenses in the Blackhawk Formation, and a continuous regional system in the coal seams and adjacent rocks of the lower Blackhawk Formation and the underlying Star Point Sandstone. A principal factor influencing the distribution and availability of ground water in these systems is the geology.

### Geology

#### *Stratigraphy*

An offlap (regressive) sequence is exposed in the outcropping Cretaceous rocks within the CIA. Strata exposed in and adjacent to the CIA, shown on the geology map on Figure 3 (Appendix A) and the generalized cross-section on Figure 4 (Appendix A), range in age from Late Cretaceous to Tertiary (Eocene).

The oldest rocks exposed in or adjacent to the CIA are upper members of the Mancos Shale, which crops out in Huntington Canyon below Electric Lake and forms the surface of Castle Valley. The Mesaverde Group overlies the Mancos Shale and consists of the Star Point Sandstone, Blackhawk Formation, Castlegate Sandstone and Price River Formation. Overlying the Mesaverde Group are the North Horn and Flagstaff Limestone of the Wasatch Group, deposited in the very late Cretaceous and Tertiary periods. Except for well-developed soils in Pleasant Valley, quaternary sediments are generally limited to narrow, thin alluvium and colluvium deposits along valley bottoms.

The Mancos Shale consists of marine shales interbedded with sandstones and minor amounts of limestone. These shales are good aquicludes, with typically low horizontal and vertical permeability, even near faults. Information discussed later in this CHIA suggests that water may flow through some faults more readily than usually observed. The Mancos is a thick, regional aquiclude that hydrologically isolates deeper strata from the coal mining and reclamation operations considered in this CHIA. The Upper Blue Gate (formerly Masuk) Shale Member at the top of the Mancos grades upward into the Star Point Sandstone, and westward-thinning wedges of marine shale intertongue with and are considered part of the Star Point.

The Star Point Sandstone was deposited in a barrier-beach environment. It consists of three main tongues – from lowest to highest, the Panther, Storrs, and Spring Canyon - that thin eastward and are separated by tongues of marine shale. A report prepared by Kravits Geological Services, LLC for the Skyline Mine identifies a Trail Canyon Tongue, just below the Panther Tongue, in the Skyline Mine area. Bedding in the sandstones is often massive. West of the outcrops, along the Wasatch Plateau escarpment, the sandstone tongues thicken and merge and then grade into the backbarrier, coastal plain, and deltaic deposits of the Blackhawk Formation. Because of the regressive depositional sequence, the lowest Blackhawk coal seam – the Hiawatha or O'Connor - usually lies on, or just above, the top of the Star Point Sandstone.

Doelling (1972) described the Star Point as almost devoid of shale in the Scofield area. Spieker (1931, p. 25) described the Star Point as uniformly 400 to 500 feet thick in exposures along the Wasatch Plateau escarpment, between Gordon Creek (west of Helper) and Ferron Canyon, but also noted the Star Point is 600 feet thick in central Huntington Canyon and over 1,000 feet thick along Mud Creek. A petroleum exploration well drilled just west of the Skyline Mine (in NE1/4 SE1/4 Sec 16, T. 13 S., R. 6 E) encountered a 1,200-foot thick sequence of Star Point Sandstone that consisted of sandstone layers, with a combined thickness of over 800 feet, inter-bedded with shale.

The Star Point is generally a poor aquifer, due in part to low permeability shale lenses, but water bearing characteristics are greatly enhanced by localized faulting, fracturing, and jointing. The large discharge and low seasonal variability of baseflow to Mud Creek and of springs along the Pleasant Valley fault zone indicate the Star Point has a large storage coefficient and relatively high transmissivity (Wadell, et al, 1983b, p. 78).

To better understand the geology of the Skyline area and to have better data for a numeric hydrologic groundwater model of the area, Kravits Geological Services, LLC compiled additional geologic information for the area in November 2003. The compilation consisted of drill hole information collected from 16 oil and gas wells and 73 coal exploration holes. The study focused on mapping the Star Point Sandstone, and primarily on the Storrs, Panther, and Trail Canyon Sandstone Tongues, which are likely the transmissive units supplying water to the Skyline Mine. The report states that the Trail Canyon Tongue is a more recently recognized tongue that lies just below the Panther Tongue. The sandstone tongues vary between 2 and 211 ft thick and average 44 ft thick. They are composed of relatively clean, fine to medium grained quartz sand, with sparse matrix, and 8 to 12% cement. The tongues have an average porosity of 16% and average permeability of 90 millidarcies based on work to the southeast.

The groundwater encountered by the Skyline Mine appears to be predominantly supplied by the underlying Star Point Sandstone. Although significant water has been discharged (56,000 acre-ft from January 2000 through October 2004), the Star Point Sandstone has a significant areal extent, reaching beyond the CIA, and does not appear to be affected in areas where the Star Point Sandstone water is being put to beneficial use.

The Blackhawk Formation consists of approximately 1,500 to 1,900 feet of lenticular claystones, siltstones, sandstones, and coal seams deposited in backbarrier, coastal plain, and deltaic environments. The claystones contain high percentages of montmorillonite and other swelling clays (Coastal, 1993, p. PHC2-3). The Blackhawk is the main coal bearing formation in the Wasatch Plateau. The important coal seams occur in the lower 350 feet, which is the section that inter-tongues with the Star Point Sandstone. The lower Blackhawk and upper Star Point are usually considered to be one continuous aquifer.

Fluvial channel sandstones are found in the lower Blackhawk but are more frequent toward the top of the formation. These sandstones are local in extent, generally fine grained, and

well cemented. They have localized high clay content. The discontinuous character of these channel sandstones and the abundance of clay throughout the Blackhawk Formation produce perched aquifers and favor formation of local flow systems that discharge through numerous seeps and springs.

The Castlegate Sandstone, the basal part of the Price River Formation, is typically massive, resistant to erosion, and white to gray in color. It consists of fluvial pebble conglomerates and fine- to coarse-grained, argillaceous sandstones with some shale. It is carbonaceous in the Book Cliffs, but the coal is thin and lignitic. The Castlegate Sandstone is good aquifer material, with seeps and springs common at the Castlegate-Blackhawk contact. The Price River Formation is light-colored, medium-grained and shaley sandstone interbedded with roughly an equal volume of darker, carbonaceous shale or mudstone. There are large point-bar sandstones, and also minor amounts of coal.

The Mesa Verde Group is overlain by the North Horn Formation, which is exposed along the top of the ridge in the western part of the CIA. The North Horn is composed of bentonitic, calcareous, silty, shales interbedded with thin limestones and fine-grained sandstones, and minor amounts of conglomerate. There are lenticular channel-sandstones throughout, enclosed by the fine-grained shales.

The Tertiary Flagstaff Limestone, which lies outside of the CIA to the west, is the youngest consolidated rock in the region. Fracturing and dissolution can produce good permeability in this lacustrine limestone, and it is an aquifer thick and extensive enough to receive and store adequate recharge.

### Structure

Surface elevations vary from 7600 feet to 10400 feet within the CIA, with the Star Point Sandstone and Blackhawk Formation outcrops forming most of this relief.

The CIA lies on the Clear Creek anticline, primarily on the west flank. Dips on the west flank range from three to six degrees, to the southwest at the south end of the CIA and to the northwest at the north end.

The Pleasant Valley fault zone, one segment of a regional fault zone that extends north south across the Wasatch Plateau, lies on the axis of the Clear Creek anticline. Total vertical displacement is 800 to 900 feet, down to the east. Intertongued Star Point Sandstone and Mancos Shale crop out west of the fault zone, but the Blackhawk Formation crops out on the east. Mud Creek flows north along the Pleasant Valley fault zone to Scofield Reservoir, where the fault zone broadens to become the Pleasant Valley Graben. U.P. Canyon, where Skyline's waste rock disposal site is situated, also follows one of the faults of this zone. Strata east of the fault zone, but within the CIA, are generally flat lying (Figure 3, Appendix A).

Other major faults in the CIA are high-angle, normal faults that run north south to northeast southwest. Movement is dominantly down to the west. The largest of these faults,



with up to 350 feet of displacement, is the O'Connor fault that obliquely transects the White Oak permit area. The Connelville fault zone, up to 1000 feet wide with up to 250 feet cumulative vertical displacement, separates the Skyline and White Oak mines. Upper Huntington Creek and Electric Lake lie along the Upper Joe's Valley fault zone that includes the Diagonal fault, which is paralleled on the east by the Valentine fault. The Joe's Valley, Diagonal, Valentine, and smaller unnamed faults do not have significant vertical displacement within the CIA. All of these faults gradually die out to the north and do not extend beyond the northern CIA boundary. The O'Connor and Upper Joe's Valley faults continue southward outside the CIA. Very small displacement faults, oriented roughly east west, have been encountered in the White Oak Mine and mapped on the surface at the Skyline Mine (Figures 3a and 3b, Appendix A). Four major joint and fracture orientations have been mapped underground and at the surface.

Some of the smaller east-west trending faults have been intruded by magma that solidified to form dikes. A major dike passes through the White Oak Mine, extending from Mud Creek to the Connelville fault. Coal has been coked adjacent to this dike and has a slightly increased metal content. There is evidence these dikes affect the movement of ground water in the shallow perched systems (Figures 3a, 3b, and 4, Appendix A). Most of the approximately north-south trending faults located west of the Connelville fault die out, or terminate in the area of an east-west trending fault in Sections 22, 23, 24, Township 13 South, Range 6 East. North of this fault the majority of the faults and fractures trend east west. These faults appear to be sub-parallel to the Fish Creek Graben located a few miles north of the Winter Quarters/North Lease area. Canyon Fuel measured the in-situ stresses in the rocks of Mine No. 3 (generally to the north); the results indicated that the rocks were in compression in an east-west direction. Similar tests conducted in Skyline Mine No. 2 (generally to the south) indicated the rocks were in extension in an east-west direction.

#### Aquifer Characteristics

In the CIA, the Star Point Sandstone, Blackhawk Formation, Castlegate Sandstone, Price River Formation, North Horn Formation, and Quaternary deposits all contain potential reservoirs or conduits for ground water. Reservoir lithologies are predominately sandstone. Sandstone reservoirs occur where there is sufficient intergranular porosity and permeability in lenticular fluvial-channel and tabular overbank deposits. Shale, siltstone, and cemented sandstone beds act as aquitards or aquicludes to impede ground-water movement. The Mancos Shale is a regional aquiclude that limits downward flow. Localized aquitards can occur within any of the more permeable formations. Ground water in the CIA occurs under both confined and unconfined conditions.

Shallow, perched ground water systems provide water to the seeps and springs issuing at the Castlegate Sandstone-Blackhawk Formation contact and from sandstone lenses of the Blackhawk Formation. The Blackhawk sandstone lenses are discontinuous and of local extent. Springs and seeps discharge on the slopes at an elevation considerably above nearby streambeds. The majority of seeps and springs issue from the west dipping strata on west facing slopes, often at a shale-sandstone interface. Flow varies seasonally in response to precipitation and snowmelt.

The perched systems may provide some flow directly to alluvial and colluvial fill in canyon bottoms, but they do not provide sufficient baseflow to sustain perennial streams. A total of 25 springs, 18 ground water wells, 38 stream sites, and 6 in-mine sites are continually monitored as part of the Skyline permit. Figure 5 (Appendix A) illustrates all of the monitoring sites within the CHIA.

Recharge percolates from the surface downward until shale, or another aquiclude is encountered. The water then moves down dip, and is channeled into discontinuous, but more permeable, sandstones creating isolated aquifers. Water in these isolated aquifers either continues to move down dip until it is discharged at the surface, or until it is able to resume vertical flow. Discharge from most seeps and springs in the CIA closely tracks precipitation rates, and recharge probably originates in the small surface depressions or basins in the immediate vicinity. The perched system of the Blackhawk Formation and regional Star Point Sandstone are separated by unsaturated rock. Flow along faults and fractures through the Blackhawk Formation appears minimal, due to the sealing ability of the clays (see section 2.3 of the Skyline Mine MRP), but some recharge does move below the perched systems to reach the deeper regional saturated strata or aquifer. Results from the age-dating techniques used at the Skyline Mine suggest that a portion of the water encountered at the mine has a modern component (i.e. in contact with the atmosphere post 1950's). PacifiCorp's tritium study also indicates a modern component.

Figure 5a provides flow data for selected springs around Electric Lake compared to the Surface Water Supply Index (SWSI). Though a few of the springs showed no reduction in flow with the 2000-2004 drought, those that did show reduced flow are consistent with the drought conditions.

Figure 5b provides flow data for selected stream locations in the Upper Huntington Creek basin. There have been no notable reductions in flow, except those attributed to the drought conditions experienced since 2000.

The Skyline Mine has encountered significant inflow along the faults solely from the floor of the mine. Any inflows encountered from the roof have been of limited duration, which is consistent with roof flows from the Blackhawk Formation at other mines.

A regional ground water system is located in saturated coal and rock of the lower Blackhawk Formation and Star Point Sandstone. Observation wells show that the water in this deeper regional system resides beneath the headwater drainages in the CIA and has not shown influence on the seeps and springs of the shallower perched systems. The Skyline Mine has historically been a relatively dry mine, with occasional roof drips, and occasional channel sandstones that typically dry up immediately or flow for a brief period. The mine did not start producing significant amounts of water until 2001, when they started encountering fracturing and faults in the floor of the mine, which were the source of the large inflows. The theory that a large portion of the water is coming from a deep regional aquifer located in the Star Point Sandstone is supported by the performance of the JC-1 and JC-2 wells, and the drawdown noted in the areas surrounding JC-1. A potentiometric surface map of the regional aquifer provided by

Canyon Fuel Company (last updated November 11/02, drawing 2.3.4-2 Skyline MRP), and more recent well-level measurements (updated quarterly, see the Division's Coal Water Quality Database at <http://linux1.ogm.utah.gov/cgi-bin/appx-ogm.cgi>) indicate that the gradient is generally from southwest to northeast in the Skyline permit area. Until March 1999, a long-term decline of water levels in the wells, typically less than 3 feet per year, was attributed to long-term decreases in precipitation and to dewatering of the aquifer by mining (Coastal, 1993, PHC2-4, Figure 3c). The long-term draw down of the aquifer was observed in wells W79-26-1 and W79-35-1B, which saw declines of 48 feet and 15 feet, respectively from 1982 through June 2003 (Figure 3c, Appendix A). Well W79-35-1A showed an 88-foot elevation drop from 1982 through 1998. From March 1999, until Canyon Fuel completed mining of the 12LB panel and allowed the southwestern portion of the mine to start flooding in January 2004, the Mine encountered significant water from fracture/fault zones, (primarily from the Diagonal Fault), and systematically drew down the potentiometric head of the Star Point Sandstone. Two wells that illustrate the draw down are wells W79-35-1A and W2-1, whose potentiometric surfaces dropped 318.26 feet and 226.1 feet, respectively from 1999 through June 2003. Both wells have started recovering since the southern portion began flooding in January 2004 (103 feet and 57 feet respectively through June 2005, see Figure 3c). Although 19 ground water wells exist within the Skyline Mine permit area, well W79-35-1B is the only well completed in the Blackhawk Formation that does not penetrate the coal seam or the Star Point Sandstone. Figure 3c illustrates that the drawdown of the Star Point aquifer is focused primarily along fault and fracture lines.

Natural discharge from the regional groundwater system occurs as baseflow into Mud Creek and the lower reaches of its perennial tributaries, and into Huntington Creek downstream of Electric Lake. Natural discharge also occurs as seeps and springs at faults and along the outcrop of the impermeable Mancos Shale. The Mancos Shale outcrop delimits the lateral extent of this regional aquifer. Water is unable to flow downward through the Mancos at any significant rate, so prefers to flow laterally through more permeable overlying strata until it discharges at the surface. Little is known of the Blackhawk-Star Point aquifer to the west, but it does not crop out and is considered to extend beneath the Sanpete valley.

As evidenced by Skyline's monitoring well at the waste rock disposal site, the regional aquifer continues to the east of Mud Creek in the Blackhawk-Star Point strata. Water supply wells in alluvium along Pleasant Valley produce from a shallow, unconfined aquifer interconnected with Mud Creek. The connection between this alluvial aquifer and the regional Blackhawk-Star Point aquifer is not uniform, but areas have been identified where ground water flows through the Pleasant Valley fault from the regional aquifer to the alluvial aquifer and directly to Mud Creek. During periods of low flow, water in Mud Creek comes mainly from seepage from the regional aquifer (Waddell and others, 1983b, p. 34).

Faulting has only local importance in the Blackhawk Formation because clays tend to seal fractures and stop or restrict water movement. On the other hand the clay content of the Star Point Sandstone is low, therefore, fractures are not as readily sealed by clay as in the Blackhawk (see Section 2.3 of the Skyline Mine MRP), and secondary permeability created by fracturing

increases the mobility of water through the regional system. Observations within the Skyline Mine suggest that sections of major faults (e.g. Diagonal and Connelville) where vertical displacement is less pronounced (0-200 ft), do not seal off, and do act as conduits for water to flow. Conversely, sections of faults with large vertical displacement result in gouge-filled, low permeability fault zones that do not produce significant amounts of water. This is evident in the performance of wells JC-1 and JC-2 located in James Canyon of the Skyline Mine permit area. Both wells were drilled as production wells to intercept water before it entered the mine. JC-1 is a 14 1/4-inch diameter well with a 60-foot screen-interval that is completed within the Diagonal fault/fractured Star Point Sandstone approximately 70 feet below the Skyline mine workings, and currently (Jan. 2006) pumps approximately 4,000 gpm. JC-2 is a 20-inch diameter well with a 60-foot screen drilled from the same site as JC-1, but at a different angle. Unfortunately, JC-2 was not completed within a fractured portion of the Star Point Sandstone and pump tests showed that it would only yield approximately 350 gpm. Due to the low yield, JC-2 was only pumped for a very short time, and no plans exist to pump there in the future. Because JC-2 had such a low yield, Canyon Fuel was forced to drill a third well, JC-3, to increase dewatering from the 10-Left area of the mine. JC-3 was completed in the mine workings near the 10-Left inflow.

Horizontal and vertical hydraulic conductivities in the Star Point Sandstone, as measured by Core Laboratories, Inc. in Dallas, Texas, are on the order of  $10^{-2}$  ft/day. Horizontal hydraulic conductivities in the Blackhawk range from no measurable permeability, to  $10^{-8}$  ft/day in the shales, and  $10^{-9}$  to  $10^{-7}$  ft/day in the siltstones. Vertical hydraulic conductivities may be greater or smaller, but are within one order of magnitude of the corresponding horizontal hydraulic conductivity. Sandstones in the Blackhawk Formation have hydraulic conductivities similar to those of the Star Point Sandstone (Lines, 1985).

A pair of drawdown/recovery tests conducted in a test well near the Skyline portal found the transmissivity of the Blackhawk to be approximately 18 gal/day/ft ( $2.4 \text{ ft}^2/\text{day}$ ). No significant difference was noted between the coal zone and sandstone tongue (Vaughn Hansen Associates, 1979, p. 85). Transmissivity of the entire Blackhawk-Star Point aquifer, based on pump tests and core analyses from the Trail Mountain area, ranges from 20 to  $200 \text{ ft}^2/\text{day}$ . The storage coefficient averages about  $10^{-6}$  (ft/ft) for confined conditions and about 0.05 (ft/ft) for unconfined conditions (Lines, 1985, p. 15). As part of the numeric hydrologic modeling conducted for Canyon Fuel Company, the estimated or bulk hydraulic conductivity ( $K$ ) for the Star Point Sandstone, using several analytical techniques, was found to be approximately 2 ft/day, and the specific storage to be approximately  $6 \times 10^{-6} \text{ ft}^{-1}$  in the vicinity of the Skyline Mine. Conversely, the modeling assumes  $K$  values of about 1 ft/day in the Star Point Sandstone outside of the zone of north-south fracturing, where historic inflows were much lower. Except as described below, the small-displacement faults are assigned  $K_h$  values of 0.001 ft/day in the upper portions of faults (within the overburden) and  $K_h$  values of 1.0 ft/day within the sandstone units below the Lower O'Connor B coal seam. The Diagonal Fault is assigned a  $K_h$  value in the sandstone of 10 ft/day generally, and 20 ft/day beneath the mine.

## Seeps and Springs

### Skyline

In 1978, 174 seeps and springs were identified on, and adjacent to, the Skyline permit area, of which 30% were seeps. This is roughly one spring or seep for every 40 acres. The seeps and springs exhibited higher flows in the springtime than at other times of the year. Many seeps and springs dried up completely during the summer, and by fall most of the remaining sources flowed less than 2 gpm; only four springs flowed more than 10 gpm in the fall. (Coastal, 1993, p. 2-24a and -25a). A survey of the White Oak mine area in 1978 and 1979 found 94 flowing, and 15 dry seeps and springs (Valley Camp, 1993, p. 700-7). In early summer, 8 of the sources had flows greater than 10 gpm, but by autumn most springs were flowing less than 1 gpm and many could not be located (Engineering-Science, 1984, p. 33). Another survey of the White Oak area in the summer of 1990 identified 81 flowing, and 43 dry seeps and springs (Valley Camp, 1993, p. 700-7). Anticipating the addition of the Winter Quarters/North Lease tract, Canyon Fuel conducted another spring and seep survey in 1993, from which they selected monitoring sites to characterize the new lease area. The monitored springs have exhibited an overall decrease in flow (Coastal, 1993, p. PHC2-6; Valley Camp, 1993, p. 700-6). The Skyline and White Oak surveys probably include duplicate information on some springs because the two permit areas abut.

Due to the significant inflows encountered in the Skyline Mine since August 2001, Canyon Fuel has increased monitoring of the seep and spring flows within the Skyline permit area. All of the seeps and springs in the Skyline groundwater monitoring program are located within the Blackhawk Formation; none have indicated a draw down or an obvious decrease in flow that can be correlated to the mine inflows.

No seeps or springs have been found at Skyline's waste rock disposal site (Coastal, 1993, p. 2-30a).

### White Oak

According to the Seep and Spring survey conducted in the White Oak permit area in the summer of 1990, a total of three seeps/springs would be affected by surface mining at that mine. Seeps/springs S25-13, S25-14, and 30-1 are all located up gradient of the surface mining. Seep/spring S25-13 is the only site that provided consistent enough flow to be continually monitored. Recorded quarterly flow measurements from site S25-13 range from 0 to 60 gpm, and average <5 gpm. It was anticipated that any flow from the three seeps or springs would still report to Whisky Creek and not be significantly impacted by the surface mining. The Division completed reclamation of the White Oak Mine in late 2005, including a restoration of Whisky Creek and installation of French drains where necessary to conduct seep/spring flow to the creek.

Seeps and springs often issue at shale-sandstone interfaces. Flow along faults and fractures through the Blackhawk Formation appears minimal, due to the sealing ability of the clays abundant therein (see Section 2.3 of the Skyline Mine MRP).

#### Electric Lake Seepage

Beginning in November 2002, Electric Lake (a man-made reservoir) has been included in the CHIA due to its proximity to the Skyline Mine. Skyline Mine comes within approximately 500 feet horizontally and approximately 850 feet vertically of Electric Lake. Information provided by PacifiCorp (owner/operator of Electric Lake Reservoir) suggests the reservoir has lost appreciable amounts of water coinciding with the major inflows encountered within Skyline Mine beginning in September 2001. Prior to June 2002, performance of the reservoir was based on reservoir elevation and discharge from the dam; inflow data to the reservoir was then back calculated (assuming no water was lost to infiltration). From June 2002 through spring runoff 2003, then June 2003 to present, actual inflow data has been collected for the reservoir, including the water pumped in via the James Canyon Wells. These will provide additional hard data to include with the reservoir performance data, and to more readily quantify what volumes of water are being lost to the surrounding geologic formations. The data provided by PacifiCorp (PacifiCorp 2003, 2004; HAL 2005) do show that the performance of the reservoir has changed substantially since 2001. However, none of the 16 springs and streams feeding into Electric Lake that are part of the Skyline Water Monitoring program have demonstrated the type of reduced water availability that has been recorded in the lake.

#### Stream Seepage

Based on flow duration curves, approximately 19% of Huntington Creek's streamflow above Electric Lake is attributed to ground water baseflow, but baseflow accounts for nearly 64% of the annual flow in Eccles Creek. This difference is, in part, because the continuous, saturated lower Blackhawk-Star Point aquifer forms approximately 25% of the surface of Eccles Canyon but is not exposed in upper Huntington Canyon. In upper Huntington Canyon ground water comes only from thin, localized, perched aquifers associated with sandstone lenses of the upper Blackhawk Formation (Vaughn Hansen Associates, 1979, p. 63 and 68).

Seepage studies were done in Eccles Creek, South Fork of Eccles Creek, and Huntington Creeks. There is a significant increase of flow in Eccles Creek where the stream crosses onto the Star Point Sandstone outcrop. There is another significant increase at the O'Connor Fault where the fault conveys water through fractured Star Point Sandstone to the stream. In comparison, the Connelville fault does not add significantly to flow in either the Main or South Fork of Eccles Creek because potential flow paths through the fractured Blackhawk Formation have apparently been sealed by clays. Observations within the Skyline Mine suggest that sections of major faults (e.g. Diagonal and Connelville) where vertical displacement is less pronounced (0-200 ft), do not seal off, and do act as conduits for water to flow. Conversely, sections of faults with large vertical displacement result in gouge-filled, low permeability fault zones that do not produce significant amounts of water.

Changes of streamflow in Huntington Creek can be largely accounted for by inflow from tributaries and hillside springs. Loss of flow just above Electric Lake is attributed to recharge into the alluvium (Vaughn Hansen Associates, 1979, pp. 68 - 80).

### Water in Mines

The coal seams mined within the CIA are located in the lower Blackhawk Formation, within strata included in the Blackhawk-Star Point aquifer. The saturated conditions encountered in the White Oak and Skyline Mines have been along fracture and fault zones, and have persisted as mining has progressed down dip. Similar conditions were found in the Utah #2 Mine, a pre-SMCRA mine, while it operated in Pleasant Valley (near the White Oak Loadout). Slight declines in the water levels of wells completed in the Blackhawk-Star Point aquifer in the vicinity of the Skyline Mine, (typically less than 3 ft per year) can be attributed to both decreases in precipitation (drought periods), and to dewatering of the aquifer by mining (Coastal, 1993, Figures PHC2-4, July 2002 Addendum to the PHC). Ground water flow into the mines can be characterized as:

- Seepage from the coal seams and associated channel sandstones,
- Flow from Blackhawk channel sandstones that have been fractured by faulting and folding, or
- Flow coming up from the Star Point Sandstone through the Blackhawk by way of faults and fractures.

Discharge from coal seams and channel sandstones average approximately 10 gpm per active mine face, but flow of 200 gpm was encountered at the Connelville fault in the White Oak Mine. Water production in the mines typically declines rapidly over a short time. Most inflows dry up by the time mining has advanced 500 feet beyond them, but an occasional roof bolt dripper will continue to flow up to 2 gpm for an extended time (Coastal, 1993, p. 2-49). A 200gpm flow from the Connelville fault observed in the White Oak Mine decreased to 10 to 15 gpm over a four-day period. These observations indicate that permeability is most likely localized, and recharge to the saturated areas is not extensive. Permeable zones in the Blackhawk sandstones are capable of yielding large quantities of water from storage for a short period of time, but are not extensive enough to have sufficient storage or recharge to sustain flows. Seasonal fluctuations of inflow have been observed and are attributed to both seasonal recharge and to subsided areas that intercept surface runoff (Engineering-Science, 1984).

Faulting typically has only local importance in the Blackhawk Formation because the high clay content tends to seal fractures, and movement of water along most faults appears to be effectively blocked or restricted by these clays. Of the 44 individual fault planes encountered up to 1988 in the Skyline Mine, only 5 dripped water from the roof (4 of those where faults intersected sandstone paleochannels). During the same period of time, water discharged up through the floor from the Star Point Sandstone along two other faults (Coastal, 1993, p. 2-24).

Fracturing in the Star Point Sandstone is not as likely to be sealed by clays as in the Blackhawk and as a result, secondary permeability created by fracturing tends to increase the mobility of water through the Star Point. Flows of up to 450 gpm were measured from the Pleasant Valley fault zone in the Utah #2 Mine. At different times, flow from the Clear Creek mine portal has been reported to be between 100 and 300 gpm (Waddell and others, 1983b; Engineering-Science, 1984). When Division personnel checked this portal in September 1993, water was still flowing at approximately the same rate, however as of 2003 water was no longer flowing from the portal. Most of the water that flowed into the Clear Creek Mine came from the Pleasant Valley fault. Water from Mud Creek was intercepted upstream of the mine and reached the fault by way of abandoned mine workings and through the Star Point Sandstone (Wadell, et al., 1983b). Because of the Pleasant Valley fault zone, it is expected that mines east of Mud Creek will typically have larger, more persistent inflows than mines on the west side.

North Joe's Valley fault has little offset and is not a major structural feature within the CIA. Flow of water from the surface into the mine, through the Blackhawk Formation by way of the North Joe's Valley fault zone, would not be anticipated because of the sealing clays in the Blackhawk Formation (see section 2.3 of the Skyline Mine MRP). In addition, the no mining buffer zone should separate mine workings from main sections of the fault along Huntington Creek and Electric Lake. This will reduce the possibility of reactivation of faults by subsidence and subsequent downward flow along the reactivated faults.

Beginning in March 1999, Skyline Mine encountered a series of major water inflows that are summarized in Table 1. These inflows are cumulatively the largest ever to occur in an underground coal mine in Utah. However, as evidenced in Table 1, the flows have steadily decreased with time, especially once Canyon Fuel allowed the southwestern portion of the mine to flood.

**TABLE 1 - Water Inflows to Skyline Mine**

<b>Inflow Location</b>	<b>Date</b>	<b>Estimated Initial Flow, gpm</b>	<b>Estimated March 2003 Flow, gpm</b>	<b>Estimated March 2004 Flow, gpm</b>	<b>Estimated December 2004 Flow, gpm</b>
14-Left HG	03/1999	1,600	300	300	14, 15, 16L
16-Left HG	12/1999	1,200	300	300	Combined 600
W. Submains (now referenced as Diagonal Fault)	03/2000	1,000	300	209	
10-Left	08/2001	6,500	3,200	3,200	
E. Submain XC5	10/2001	1,000	370	380	
11-Left HG XC24	02/2002	1,000	900	500	All other flows
11-Left HG XC40	02/2002	1,000	1,000	700	In SW portion



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11-Left Setup Rm.	03/2002	1,500	1,300	700	Combined 2,500
	<b>Totals</b>	<b>14,800</b>	<b>9,300</b>	<b>6,289</b>	<b>3,100</b>
	% of initial flow		63%	42%	21%

These inflows prompted considerable investigations by the mine and outside consultants in an attempt to find out where they were coming from and how to alleviate them. They also necessitated a revision to this CHIA in November 2002. All of the inflows were in Mine 2, which proceeded further west than Mines 1 or 3. All of these inflows are associated with faults, and enter the mine through the floor. The investigations by HCI and Petersen (Appendices C, G, and H of July 2002 Addendum to the PHC, PHC Addendum Appendix J) suggest that the water source is the Star Point Sandstone located beneath the coal seam. The Star Point in the mine area is believed to consist of 14 different sandstone layers totaling 743 feet in thickness. As discussed earlier, this formation has a large storage coefficient and relatively high transmissivity. The large number of fracture planes that make up the regional fracture network provide the surface area necessary to drain the water stored in the matrix of the Star Point Sandstone. Based on <sup>14</sup>C age dating and Tritium analysis, the water in the Star Point Sandstone is believed to be of ancient origin and represents an isolated groundwater storage volume that is not in direct connection with the surface.

Immediately after the 6,500-gpm inflow in 10L began, the mine drilled 2 wells into the fault that intercepted the 10-Left inflow. The intent was to remove ground water before it entered the mine and thus reduce inflows. Only one well, JC-1, produced appreciable water and is currently (Jan. 2006) pumping at about 4,000 gpm. This pumping was only marginally successful at reducing inflow waters and was estimated to reduce the inflow no more than 800 gpm while the well was pumping 2,200 gpm (HCI).

Based on observations within the mine, as well as other studies and data, the Star Point seems to be the source of the majority of the inflows. However, there is a component of modern water in the inflows, which *may* be coming from Electric Lake or other surface water storage.

Ground- and surface-water monitoring of streams, springs, and seeps conducted by the mine has not indicated any impacts due to the increased in-mine flows. The springs and seeps respond rapidly to seasonal and climatic cycles, indicating that the springs are fed by discharge from a shallow groundwater system. Appendix A of the Skyline Mine July 2002 Addendum to the PHC graphically outlines the flow of the springs and their response to the Palmer Hydrologic Drought Index (PHDI). Age dating of numerous springs also supports the recharge being fed from a shallow groundwater system.

It is significant to note that most of the monitoring wells available for analysis are either completed in the Star Point Sandstone, or through the coal seam in the Blackhawk Formation. The one exception is well W79-35-1B, which is immediately adjacent to W79-35-1A, but is

completed within the Blackhawk Formation, above the coal seam. The water level in Well W79-35-1B remained constant while the water level in Well W79-35-1A (screened below the coal seam) dropped approximately 300-feet during the dewatering activities in the mine (Figure 3c, 4a, and 5, Appendix A, data from the Division's Coal Water Monitoring Database). This lack of communication between the two wells suggests the effectiveness of the Blackhawk Formation in impeding vertical migration of water through the formation. Though information provided by PacifiCorp (PacifiCorp 2003, 2004) suggests that Electric Lake is losing water at an "alarming" rate; water chemistry, stable and unstable isotope analysis of the water, and dye tracer studies to date do not *confirm* a direct connection between the mine and lake (see Section VII). Based on water-monitoring data, springs, seeps, and streams entering Electric Lake do not appear to be impacted by the volume of water being discharged from the mine.

Beginning in late July 2003, Well JC-3 began pumping water directly from the Skyline mine-workings into Electric Lake at a rate of approximately 5,100 gpm. The well represented no net increase in the amount of mine-water being discharged, only a change in the point of discharge. Due to equipment failure and high TDS (limit set at 255 mg/L for discharge into Electric Lake), JC-3 ceased operation in July 2004.

#### Ground Water Usage

Hansen, Allen, and Luce, Inc. conducted a survey of water rights for the White Oak Mine in 1990. The survey covered most of the area in the CIA. A total of 135 ground water rights were found, 112 on springs and 23 on wells or tunnels. Stock watering was the declared use on 62 of the water rights, 41 were for other uses, and the remaining 32 were undeclared. The information is summarized in Table 724.100a in the White Oak MRP, and the locations are shown on Map 724.100a. Skyline Mine updated the water rights information in their MRP with the addition of the Winter Quarters/North Lease area in 2002. Springs and seeps are important to wildlife, though there are no filed rights that declare this as a use.

Both the Skyline and White Oak mines utilize water from wells in Eccles Canyon that were drilled into fault zones in the Star Point Sandstone. Wells near the Skyline and White Oak loadouts in Pleasant Valley produce water from both alluvium, and Star Point Sandstone. Water from these wells is for domestic, stock watering, and other uses.

From September 2001 (startup of JC-1 well) through September 2005, approximately 62,721 acre-ft of water have been discharged from the Skyline Mine. Of that, approximately 37,362 acre-ft have reported to Scofield Reservoir via Eccles and Mud Creeks, and approximately 25,359 acre-ft have reported directly to Electric Lake via the JC-1, JC-2, and JC-3 wells. Complete discharge records for the post-inflow period are available at <https://fs.ogm.utah.gov/pub/MINES/Coal/007/C0070005/Discharge Info/>. The discharged water is generally of good quality and has been put to beneficial use in both drainages. The major mine inflows that necessitate discharge are slowly decreasing with time. Canyon Fuel completed the mining of the southern portion of the Skyline Mine in May 2004. At that time they allowed the mine-workings in that area to flood to an elevation of 8,280 feet, which took approximately four months.

JC-1 and JC-3 are both considered as mine-dewatering wells, but only JC-3 has an associated UPDES discharge permit. JC-1 is related to mining because it encounters water that would otherwise enter the mine. It does not have an associated UPDES discharge permit because the water does not enter the mine and comes from the formation in its natural state. When mining ceases permanently, the operation of JC-1 will be terminated. JC-3 has an associated UPDES permit, held by PacifiCorp, because it pumps water directly from the mine-workings. It is the understanding of the Division that the UPDES permit for JC-3 will also be terminated once mining ceases permanently. Neither JC-1 nor JC-3 has an associated water-right.

Currently (Jan. 2006), no proven adverse effects have been observed to the existing surface or groundwater resource usage.

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## **IV. BASELINE CONDITIONS OF SURFACE AND GROUND WATER QUALITY AND QUANTITY.**

### **Surface Water – Baseline Conditions**

Surface water is monitored for quantity and quality at various stations operated by the USGS and the coal mine operators. Locations are shown on Figure 5 (Appendix A) and analysis results are found in both the Skyline and White Oak MRPs, the Mud Creek /Huntington Creek CHIA, the Division's Coal Water Quality Database (<http://linux1.ogm.utah.gov/cgi-bin/appx-ogm.cgi>) and USGS publications. Graphs of selected groundwater wells, springs and streams comparing historic flow to the Palmer Hydrologic Drought Index (PHDI) are provided in Appendix A of the July 2002 Addendum to the Skyline PHC, and were last updated with data from the 1<sup>st</sup> quarter (calendar year) of 2003. These graphs illustrate how the springs in the Blackhawk Formation respond rapidly to seasonal and climatic cycles, indicating that the springs are fed by discharge from a groundwater system that is in good communication with the surface, and with annual recharge events. Also, to assist in quantifying any potential effects to Electric Lake, PacifiCorp provided the Division with graphs and information illustrating the performance of the lake dating back to 1974. Monitoring has been infrequent or irregular at some stations. With the addition of the Winter Quarters/North Lease tract, additional studies were conducted in Winter Quarters Creek and Woods Creek due to their perennial nature and importance of fishery habitat.

### Surface Water Quantity

Average annual yield from the 22,000-acre Mud Creek drainage, as determined from continuous USGS measurements from 1978 to 1999 at station 09310700, is 15.99 cfs (equal to 6.31 inches of rain over the entire drainage per year, or 11,576 acre-ft/yr ). Discharge rates are summarized in Table 2. The highest discharges result from spring snowmelt (Price and Plantz, 1987). From September 2001 through September 2005, an additional 37,362 acre-ft of mine-water discharge ( $\approx 12.63$  cfs) has been added to the Scofield Reservoir. During that time period, total flow measured at the gauging station averaged approximately 19 cfs. A comparison of the flows encountered between 1982 through 1986 (a naturally high flow period) and 1998 through 2002 (increased mine discharge with drought conditions) indicate that the increased mine inflows were only higher than natural conditions for approximately a 6-month period (See Figure 10a). With the addition of Well JC-3, Canyon Fuel anticipated that the flow rate would decrease significantly during 2004, and stay there. However, since JC-3 is no longer operating, and all excess water must be pumped to Eccles/Mud Creek the discharge is still averaging around 9 cfs (4,000 gpm), and total flow at the gauging station averages 15 cfs.

**TABLE 2**

Discharge of Mud Creek measured near the town of Scofield.

Gauging Station	Date	Average	Maximum	Minimum
USGS 09310700	1978 - 1999 (Continuous)	15.99 cfs	300 cfs	1.4 cfs

Eccles, Winter Quarters, Boardinghouse, and Finn Creeks are the principal tributaries to Mud Creek. Based on continuous measurements by the USGS from 1980 to 1984 at station 09310600 (Price and Plantz, 1987), average annual yield from the 3,500 acre watershed in Eccles Canyon is 3,412 acre-feet/yr (equivalent to 11.7 inches rainfall per year over the entire watershed). The maximum-recorded peak flow was 71 cfs in May 1984. Skyline recorded high peak flows in 1983 through 1986. Discharge rates are summarized in Table 3.

**TABLE 3**

Discharge measured near the mouth of Eccles Creek.

Gauging Station	Date	Average	Maximum	Minimum
USGS 09310600	1980 - 1984 (Continuous)	4.70 cfs	71.0 cfs	0.62 cfs
Skyline CS-6	1981 - 1999	6.09 cfs	71.2 cfs	0.54 cfs

Skyline's data indicate that water began to be discharged from the #3 Mine in 1983, and from 1984 to 1992 discharge averaged 0.50 cfs. Discharge from Skyline Mine #1 began in 1989 and averaged 0.28 cfs from 1989 to 1992. Minimum measured discharges from #1 and #3 were 0.08 cfs and 0.13 cfs and maximums were 0.69 cfs and 1 cfs. In late summer to early autumn when streamflow is naturally low, discharge from the Skyline Mine has been estimated to account for as much as 60% to 70% of flow in Eccles Creek.

The additional 13 cfs discharged from August 2001 through September 2005 represents approximately 2 times the average flow encountered in Eccles Creek at water monitoring site CS-6 (Table 3), from 1981 through 1999. The reduced mine discharge of approximately 9 cfs represents 1.5 times the normal flow, and 13 percent of the maximum flow during that period. To monitor the impacts of this additional water to the physical characteristics of Eccles and Mud Creek, a study was initiated in the summer of 2002 and continued in the summers of 2003 and 2004. Field observations indicate the additional water makes the flow at, or just below bankfull capacity of Eccles Creek. However, Eccles Creek appears to be well armored and able to handle the additional flow. Mud Creek is larger than Eccles Creek and flows there are approximately 4-times larger than normally seen; however the flow is not as close to bankfull capacity. Results

from the study indicate no significant impacts to the stream morphology have been observed. The details of the study are outlined in Appendix D of the July 2002 Addendum to the PHC, and copies of the reports are located in the Division's Public Information Center (PIC).

Prior to the breakout of the ventilation portal in South Fork of Eccles Creek in 1989, maximum measured flow at station VC-10 was 14.7 cfs. Periods of no-flow were observed in 1981, 1984, 1995, 2001, and 2002 but never during the third or fourth quarter of the calendar year (July-December). Average measured flow from 1978 to 1990 was 1.39 cfs (Table 4).

Construction of the road to the White Oak Mine in Whisky Canyon began in 1975. Monitoring of Whisky Creek began the same year, so there are no data on conditions prior to disturbance of the drainage. Periods of no-flow have been recorded at least once in each of the four calendar quarters (Table 4). Although not as consistently dry, Whisky Creek was periodically dry from 1982 through 2000.

During average flow conditions, Whisky Creek (at VC-5) accounts for approximately 8.1 percent of the flow in Eccles Creek, and 2.4 percent of the flow in Mud Creek. Upper Whisky Creek at VC-4 accounts for approximately 15.8 percent of the flow of VC-5. The surface mining at the White Oak Mine and reconstruction of Upper Whisky Creek has impacted the area immediately surrounding site VC-4. However, any flow lost due to infiltration into the reclaimed fill should surface further downstream in Whisky Creek. Although a significant loss in flow at VC-4 would impact flows at VC-5, minimal cumulative impacts would be seen at Eccles Creek and Mud Creek.

The location of sample site VC-4 was moved upstream approximately 280 ft. due to disturbance created by the surface mining. VC-4 represents undisturbed drainage of Whisky Creek. Although moved upstream, only one small ephemeral draw was eliminated from the drainage basin resulting in an insignificant change in flow.

Lodestar Energy, Inc. declared bankruptcy and discontinued mining and water monitoring at the White Oak Mine.

**TABLE 4**

Discharges measured at South Fork of Eccles Creek and Whisky Creek

Gauging Station	Date	Average	Maximum	Minimum
South Fork White Oak VC-10	1978 - 2002	1.39 cfs	14.7 cfs	0 cfs (2 of 4 quarters)
Whisky Creek White Oak VC-5	1976 – 2002	0.38cfs	3.70 cfs	0 cfs (4 of 4 quarters)
Whisky Creek	1977 – 2002	0.06 cfs	1.0 cfs	0 cfs

Gauging Station	Date	Average	Maximum	Minimum
White Oak VC-4				(4 of 4 quarters)

Boardinghouse and Finn Creeks were not directly affected by surface mining at the White Oak Mine, but were monitored by White Oak and results are summarized in Table 5 (Valley Camp, 1993, p. 700-23). The Permittee reported no-flow for each of the five times that they were able to observe Finn Creek during a first calendar quarter.

**TABLE 5**

Discharges measured at Boardinghouse and Finn Creeks

Gauging Station	Date	Average	Maximum	Minimum
Boardinghouse White Oak VC-11	1980 - 2002	1.6 cfs	12.8 cfs	0.02 cfs
Finn Creek White Oak VC-12	1980 - 2002	0.47 cfs	4.20 cfs	0 cfs (4 of 4 quarters)

Waddell and others monitored Winter Quarters Creek in 1979-1980 and Skyline did so in 1981 and 2002-present. Results are summarized in Table 6.

**TABLE 6**

Discharges measured at Winter Quarters Creek

Gauging Station	Date	Average	Maximum	Minimum
35*	1979-1980	0.405 cfs	0.51 cfs	0.30 cfs
CS-19	2002-2005	0.561 cfs	2.90 cfs	0.05 cfs
CS-20	Nov. 1981	0.07 cfs		
	2002-2005	1.371 cfs	6.24 cfs	0.24 cfs

\* (Waddell and others, 1982)

Skyline monitors upper Huntington Creek where it discharges into Electric Lake, at station UPL-10. Flow is measured periodically when the site is accessible, mainly from May to October. From 1981 to 1993 the average flow during these accessible months was 7.8 cfs



**WATER QUALITY****Mud Creek & Upper Huntington**

(Skyline Mine 1993 Annual Report). Utah Power and Light monitored Huntington Creek above Burnout Creek prior to construction of Electric Lake, and the information is found in the report by Vaughn Hansen Associates (1979). Discharge of upper Huntington Creek is summarized in Table 7.

Average flow of Burnout Creek at station CS-7 from 1981 to 2002 was 1.2 cfs, with minimum and maximum measured flows of 0.01 and 10.7 cfs. Flow from Little Swens, Swens, Boulger, and James canyons have only recently been added to the Skyline water-monitoring program. Flow from Electric Lake is regulated for the benefit of downstream users and does not accurately characterize the hydrologic system.

**TABLE 7**

Discharge of Huntington Creek above Burnout Creek.

Gauging Station	Date	Average	Maximum	Minimum
Utah Power & Light	1971 – 1973	-	>170 cfs	□0.5 cfs
Skyline UPL-10	1981 – 2005	7.4 cfs	79 cfs	0.32 cfs

Predicted average discharge for Eccles Creek, based on flow duration curves for water years 1976 through 1978, is 5.43 cfs, corresponding to a yield of 13.4 inches of rainfall over the watershed. Flow duration curves from Huntington Creek above Burnout Creek for water years 1972 and 1973, before Electric Lake was filled, indicate an average annual discharge of 13 cfs and a yield of 16 inches of rainfall over the entire watershed per year (Vaughn Hansen Associates, 1979). The predictions are based on data from different periods, but the higher predicted yield from the upper Huntington Creek basin in comparison to that from the Eccles watershed may be a consequence of the relative impermeability of the Blackhawk Formation that forms or immediately underlies the surface over most of the upper Huntington Creek basin (Coastal States, 1993, p. 2-42), and the westward dip of the strata.

Burnout and Huntington Creeks drain 8,240 acres (42% of the upper Huntington Creek basin located above the dam), and their combined average discharge has been 6,500 acre feet per year (9 cfs). Estimating from the Burnout and Huntington Creek data, discharge from the entire 19,854 acres of the upper Huntington Creek basin located above the dam would be 16,000 acre feet per year (22 cfs). Comparing the continuous flow recorded at the mouth of Eccles Creek (Table 3) and using the same flow volume per acre of land for the Upper Huntington basin supports this estimated number. Using the same volume per acre number from the Eccles Creek drainage for the 19,854 acres, the average flow for the Upper Huntington basin is 21.2 cfs or 15,350 acre-ft/yr. Subtracting a calculated 800 acre-ft of evaporation per year, based on PacifiCorp data, the Upper Huntington drainage basin receives an average of approximately 14,500 acre-ft/yr.

### Electric Lake

Electric Lake, with a storage capacity of 31,500 acre-ft, began filling in 1974. PacifiCorp owns water shares in Electric Lake, and uses approximately 12,000 acre-ft of water annually. Since 1974, PacifiCorp (formerly Utah Power and Light) has monitored the water within the Upper Huntington drainage basin using imputed flow data, discharge records, lake levels, and precipitation and evaporation data. Since June 19, 2002, they have measured actual flow data in the Upper Huntington basin, with the exception of tributaries located below Boulger Creek, which are estimated to contribute approximately 1 cfs on average.

In July 2003, PacifiCorp submitted a report to the Division suggesting Electric Lake has been losing a disproportionate amount of water since August 2001, based primarily on the reaction of the lake (PacifiCorp – Investigation of Technical Issues related to the Electric Lake and Huntington Creek Controversy June 25, 2003). No calculation reflecting the purported volume lost from Electric Lake was provided in the original report. The report provided numerous graphs illustrating how Electric Lake intuitively appeared to be losing water. Regardless, and though much of PacifiCorp's inflow data were 'back-calculated' and hard monitoring numbers were lacking at the time, the data showed a change in the reservoir performance. PacifiCorp has since started to monitor inflow into the lake and they update and provide a detailed spreadsheet with measurable inflows and outflows, as well as lake performance data to the Division monthly. Stage volumes, natural leakage of Electric Lake, and the effects of the drought all contribute to the response being seen in the lake elevations. Whether the inflows encountered in the Skyline Mine are associated with this apparent loss of water, and to what degree, is still being evaluated (see Section VII).

### Discharge of Mine Inflows to Surface Drainages

As discussed earlier, Skyline Mine encountered considerable groundwater inflows beginning in March 1999. In an attempt to reduce inflows, wells were drilled in James Canyon to pump ground water from the fracture system 70 feet below the mine (JC\_1 and JC-2), and directly from the mine workings (JC-3) into Electric Lake. From September 2001 until September 2002 water was pumped at about 2,200 gpm from Well JC-1. In October 2002, the pumping rate in JC-1 increased to about 4,200 gpm by installing a higher capacity pump. In late July 2003, Well JC-3 began pumping directly from the mine workings at approximately 5,100 gpm and continued pumping until July 2004. JC-1 currently (Jan. 2006) operates at around 4,000 gpm. Through September 30, 2005, 25,359 acre-ft of water have been pumped from the James Canyon wells into Electric Lake and therefore, the Huntington Creek drainage. None of the 16 springs and streams feeding into Electric Lake that are part of the Skyline Water monitoring program have demonstrated the type of reduced water availability that has been recorded in the lake.

A portion of the mine inflows has also been pumped out of the mine into Eccles Creek. Since August 2001 these flows have varied from 0 to 10,500 gpm, with an average of about 5,666 gpm (through September 2005). At the peak, this increased the average flow in Eccles

Creek by 3 times normal amounts (pre-1999) and increased the average flow in Mud Creek by 1.2 times normal amounts.

The Division anticipates that the addition of the Winter Quarters / North Lease area will have minimal, if any effect on the water quantity being discharged to either drainage. This conclusion is based on past mining in the area, differences in geology from the southern portion of the mine, and an apparent lack of communication between groundwater wells located in the northern and southern portions of the permit area. The Division anticipates that any inflow to the North Lease will be infrequent, and short-term in nature.

#### Surface Water Quality

Water within the CIA is used for watering livestock and wildlife, mining coal, domestic use, fisheries, and recreation. Downstream, the water is additionally used for irrigation and industrial needs. Land within the CIA is used for wildlife habitat, grazing, recreation, and mining coal. Anticipated post-mining uses are for wildlife habitat, grazing, and recreation.

The Utah Division of Water Quality classifies (latest classification December 7, 2001) Scofield Reservoir as:

- 1C - protected for domestic purposes with prior treatment by treatment processes as required by the Utah Division of Drinking Water.
- 2B - protected for secondary contact recreation such as boating, wading, or similar uses.
- 3A - protected for cold-water species of game fish and other cold-water aquatic life, including the necessary aquatic organisms in their food chain.
- 4 - protected for agricultural uses including irrigation of crops and stock watering.

The total phosphorous in Scofield Reservoir is of concern to the Utah Division of Water Quality, and they have set the Total Maximum Daily Load (TMDL) Target Load of 4,842 kg/yr (29 lb/day)

#### Scofield Reservoir:

- Is a culinary water source,
  - Is one of the top four trout fishing lakes in Utah, and
  - Has an annual recreational fishing value of more than 1 million dollars.
- (E-mail from Louis Berg, Utah Division of Wildlife Resources, to Division dated February 4, 2002).

The Utah Division of Water Quality classifies (latest classification December 7, 2001) Electric Lake as:

- 2B - protected for secondary contact recreation such as boating, wading, or similar uses.
- 3A - protected for cold-water species of game fish and other cold-water aquatic life, including the necessary aquatic organisms in their food chain.
- 4 - protected for agricultural uses including irrigation of crops and stock watering.

Electric Lake:

- Provides cooling water for the Huntington Power Plant, and
- Is a major source of agricultural water for the Huntington Cleveland Irrigation Company.

Streams in both basins are classified as 1C, 3A, and 4.

In addition, surface waters located within the outer boundaries of a USDA National Forest, with specific exceptions, are designated by the Utah Division of Water Quality as High Quality Waters - Category 1 and are subject to the state's antidegradation policy. This antidegradation policy states that waters shall be maintained at existing high quality, and new point source discharges of wastewater (treated or otherwise) are prohibited (Utah Administrative Code, R317-2-3.2 and R317-2-12.1). All of the upper Huntington Creek drainage, and most of the headwater drainages of east flowing tributaries to Mud Creek, (including the Skyline Mine disturbed area) are within USDA Forest Service boundaries and are therefore protected by this policy. The White Oak Mine, both loadouts, and the waste rock disposal site are outside forest boundaries.

The Utah Water Quality Board agreed in their September 24, 2001 meeting to reclassify Electric Lake as High Quality Waters – Category 2. Category 2 is defined as “...designated surface water segments which are treated as High Quality Waters – Category 1; except that a point source discharge may be permitted, provided that the discharge does not degrade existing water quality.” Both the effluent from Skyline Mine (JC-3), and the lake were to be sampled for a period of two years for a full suite of metals and nutrients to ensure that the mine water is not of a lower quality of water than exists in Electric Lake. Due to equipment failure and high TDS, the JC-3 well (which discharged directly from the Skyline Mine into Electric Lake) is no longer pumping. Canyon Fuel and PacifiCorp have continued to sample the quality of water from the lake and the JC-1 well.

#### Total Dissolved Solids (TDS)

Water quality in the CIA is considered good, most being of calcium bicarbonate type. TDS levels normally vary between 100 and 400 mg/L in the headwaters regions. Higher TDS levels correspond to low flows. Calcite and aragonite are at or near saturation in the streams flowing into Scofield Reservoir, and precipitation of calcium carbonate in the reservoir is indicated by the water chemistry (Waddell and others, 1983a).

At Well JC-3 (discharging to Electric Lake) TDS is limited to a daily maximum of 255 mg/L with no daily tonnage or flow limitation. Canyon Fuel had a difficult time meeting this standard, even when blending the JC-3 and JC-1 water. For this reason they discontinued pumping from JC-3 after one year.

Skyline's monitoring station CS-6 is at the same location as USGS gauging station 09310600, near the mouth of Eccles Canyon. Skyline and USGS measurements of TDS are summarized in Table 8. Skyline measured higher concentrations of TDS between 1981 and 2002 than were measured by the USGS between 1980 and 1984. The USGS analyzed samples more frequently than Skyline. TDS concentrations had been increasing from year to year at this location and others along Eccles Creek below the Skyline Mine (Figure 6a, Appendix A). Due to the increased mine inflows and necessary discharge of them at high rates, Skyline was exceeding their UPDES daily tonnage limit for TDS (7.1 tons/day) Canyon Fuel worked closely with DWQ to remedy the situation, and after much study and effort, DWQ modified the Skyline Mine UPDES permit in May of 2003 to remove the 7.1 ton per day limit for TDS, unless the 30-day average were to exceed 500 mg/L.

The Utah Division of Water Quality (DWQ) issued the current permit on Nov. 23, 2004; it allows for a daily maximum of total dissolved solids discharged (TDS) of 1310 mg/L and a 30-day average of 500 mg/L. There is no tonnage per day (tpd) daily maximum, unless the 30-day average exceeds 500 mg/L; then a 7.1-tpd limit is imposed. The permit also states:

*Upon determination by the Executive Secretary that the Permittee is not able to meet the 500 mg/L 30-day average or the 7.1 tons per day loading limit, the Permittee is required to participate in and/or fund a salinity offset project to include TDS offset credits, within six (6) months of the effective date of this permit.*

In September of 2004, Skyline's mine discharge began averaging 850-950 mg/L TDS, and due to the volume of water pumped (approx 3500 gpm), they were routinely exceeding the tons per day limit. Because the conditions at the mine will require such pumping for quite some time, Canyon Fuel Company prepared a salinity offset plan and submitted it as required to DWQ. The Division of Water Quality approved the plan on January 5, 2005, but it is retroactive to September 2004.

USGS gauging station 09310700, on Mud Creek near the mouth of Winter Quarters Canyon and just upstream of the town of Scofield, was operated continuously during water years 1979 through 1984. TDS measurements averaged 315 mg/L with a minimum of 170 mg/L and a maximum of 390 mg/L (Price and Plantz, 1987). Monitoring station VC-1 is approximately one mile upstream of 09310700 and just below the White Oak loadout. At VC-1, the average TDS from 1975 to 2002 was 320 mg/L, with a maximum of 730 and a minimum of 156 mg/L.

**TABLE 8**  
Total Dissolved Solids (TDS) in Eccles and Mud Creeks

Gauging Station	Date	Average	Maximum	Minimum
Eccles Creek just above confluence with Mud Creek				
USGS 09310600	1980 - 1984	294 mg/L	492 mg/L	161 mg/L
Skyline CS-6	1981 - 2005	467 mg/L	1282 mg/L	198 mg/L
Mud Creek below White Oak Loadout				
USGS 09310700	1979 - 1984	315 mg/L	390 mg/L	170 mg/L
White Oak VC-1	1975 - 2002	320 mg/L	730 mg/L	156 mg/L

There is a shift from calcium toward sulfate and magnesium cations as the water flows toward Scofield Reservoir, probably due to the dissolution of evaporites in Mancos Shale tongues exposed in Pleasant Valley (Coastal, 1993, p. 33).

Figures 6 through 8 (Appendix A) show TDS concentrations from 1977 through 2005 from data submitted by Skyline and White Oak to the Division. Linear regressions of TDS concentration as a function of time were calculated, providing a rough representation of ongoing coal mining activities such as production, storage, and hauling of coal and discharge of water from the mines. Representative linear regressions are plotted on the figures. Data from the initial period of road construction during 1975 and 1976 were not used in the regression calculations because they are not representative of ongoing mine operations. Road improvement and additional construction were ongoing from 1980 to 1984, but there was not a noticeable change in TDS concentrations during this period. Other specific data omitted from regression calculations are indicated on the figures.

TDS levels in water discharged from Skyline's sediment pond began exceeding the UPDES maximum of 1000 mg/L (753 mg/L annual average) on a regular basis in November 1990. Sulfate concentrations also exceeded the 500 mg/L UPDES limit in most of these high TDS samples. Leaching of sulfate from rock dust in flooded, abandoned areas of the Skyline Mine was the source (ERI, 1992). In May 1994, the Utah Division of Water Quality raised the daily limits to 1600 mg/L TDS and 1000 mg/L sulfate on an interim basis through September 1994, with TDS and sulfate levels to meet requirements of the regular UPDES permit at the end of the interim period. The current daily maximum UPDES limit for TDS is 1300 mg/L, with a limit of 500 mg/L averaged over 30 days. There is no limit for sulfate in the current UPDES permit.

TDS concentrations in lower Eccles Creek are diluted between CS-2 and VC-9 by inflow from South Fork and Whisky Creek and baseflow from the Star Point-Blackhawk aquifer. Further dilution occurs when Eccles Creek flows into Mud Creek, but still TDS concentrations have increased at VC-1 and VC-2 (Figure 7, Appendix A).

TDS concentrations have remained nearly constant at CS-3 and CS-9 above the Skyline Mine (Figure 6b, Appendix A). Linear regressions of data from stations CS-11 (Figure 6b, Appendix A) and CS-4 above the Skyline Mine and from CS-1 and VC-10 (Figure 6c, Appendix A) in the South Fork of Eccles Creek indicate TDS concentrations have generally increased with time at CS-11, CS-4, and VC-10 but at a lower rate than in the samples taken downstream of the Skyline Mine. TDS concentrations at CS-1 have actually decreased.

In Whisky Creek, TDS concentrations steadily increased at VC-5 below the White Oak Mine from approximately 300 mg/L to close to 1000 mg/L (Figure 6d, Appendix A). The rate of increase is similar to that in lowermost Eccles Creek. Since Whisky Creek accounts for approximately 8% of the flow of the Eccles Creek, this is a minor contribution to the overall balance of the stream. White Oak reported 4000 mg/L TDS at VC-5 on June 27, 1986, a singular anomaly possibly caused by road salt getting into the stream (Valley Camp of Utah, 1993). At VC-4 (Figure 6d, Appendix A) above the White Oak Mine, TDS concentrations appear to have remained consistent. TDS values at VC-4 have consistently remained below 200 mg/L.

The surface-mining methods that the White Oak Mine employed had little impact on the TDS reporting into Eccles Creek. Acid and Toxic-forming testing of the geology in the area demonstrated a high neutralizing potential of the sediments, and low toxicity. Geologic units containing elevated levels of selenium and metals were buried with at least 4 feet of cover, and were placed outside of the floodplain of Whisky Creek.

The TDS in Huntington Creek at UPL-10, above Electric Lake, varied from 80 to 442 mg/L, and averaged 185.9 mg/L from 1981 to 2005. Figure 8 (Appendix A) shows TDS concentrations for stations upstream of Electric Lake. TDS concentrations appear to have changed little with time in this drainage.

At UPL-3 just below the outlet from Electric Lake, TDS averaged 156.7 mg/L from 1981 to 1991 and ranged from 130 to 210 mg/L (Coastal, 1993, Volume 4). TDS in Huntington Creek at USGS gauging station 09318000 near the town of Huntington was 165 to 345 mg/L between June 1977 and September 1979. TDS in the Price and San Rafael Rivers where they flow into the Green River is 1500 to 4000 mg/L.

#### Iron and Manganese - Dissolved

From 1979 to 1984, measurements of dissolved iron at USGS gauging station 09310700 in Mud Creek above Scofield ranged from 0.003 to 0.150 mg/L.

Water analyses done for the White Oak Mine only sporadically included dissolved iron, and only included dissolved manganese from 1995 to 2003. The highest value for dissolved iron reported by the White Oak Mine is 6.65 mg/L at VC-13, a sampling station in Long Canyon. The highest value measured in Whisky Creek, below the White Oak Mine at VC-5, was 1.45 mg/L (October 1982). The highest dissolved iron found in Eccles Creek by White Oak was 0.76 mg/L at VC-6 in August 1980. With the exception of a one-time dissolved iron value of 7.65 mg/L at VC-4 in 1982, Whisky Creek had very low dissolved Iron and Manganese values.

Maximum dissolved iron (in surface water) reported by Skyline, between 1980 and 2002, was 0.36 mg/L at CS-2 in Eccles Creek (1992). Maximum dissolved manganese was 0.2 mg/L, also at CS-2.

Dissolved iron in Huntington Creek at station UPL-10 above Electric Lake varied from 0.03 to 0.16 mg/L, and averaged 0.09 mg/L from 1981 to 2002. Dissolved manganese varied from 0.01 to 0.10 mg/L and averaged 0.06 mg/L.

#### Iron and Manganese - Total

Total iron averaged 2.7 mg/L and total manganese averaged 0.15 mg/L at sites monitored for the White Oak Mine from 1975 through 2002. The highest reported concentration of total iron was 88.5 mg/L, and for total manganese it was 7.15 mg/L. Both samples were from VC-5 on Whisky Creek, but were collected at different times. High total iron concentrations have been reported by Skyline at several locations, the highest being 45.10 mg/L at CS-9, above the Skyline Mine in the north fork of Eccles Creek. Total manganese concentrations reported by Skyline have ranged from 0.01 to 1.06 mg/L. Price and Plantz (1987) do not report total iron or total manganese concentrations.

Data from CS-6, near the mouth of Eccles Creek, show that total iron ranged between <0.05 and 24.5 mg/L from 1981 to 2005, and averaged 1.2 mg/L. At monitoring station VC-1 on Mud Creek, just below the White Oak Loadout, average total iron from 1977 to 2002 was 1.11 mg/L. The maximum was 7.66 mg/L and the minimum was 0.015 mg/L.

Total iron in Huntington Creek at station UPL-10 above Electric Lake has varied from 0.09 to 0.72 mg/L and averaged 0.34 mg/L from 1981 to 2002. Total manganese varied from 0.019 to 0.07 mg/L and averaged 0.03 mg/L. At UPL-3, just below Electric Lake, total iron averaged 0.2 mg/L from 1981 to 1991 and ranged from 0 to 1 mg/L. Total manganese was below detection limits (Coastal, 1993, Volume 4).

#### Nickel

The Skyline Mine PHC states that nickel concentrations have reached as high as 40 µg/L in the water that they discharge to Eccles Creek. This level is greater than the 15-µg/L known to inhibit the reproductive capabilities of *Ceriodaphnia dubia*, an invertebrate biologic indicator species, but below the chronic and acute criteria, for both aquatic wildlife and human health, in the Standards of Quality for Waters of the State. As the flows increased from 1999 through



2001, there initially were indications of toxicity from high nickel concentrations and high TDS. The significant inflow to the mine from the 10-Left area and changes of how water is handled underground resulted in a decline in TDS and dissolved nickel over time.

The source of this nickel is not identified. Nickel is not typically found in the Wasatch Plateau, neither is it commonly associated with the other atypical metals (copper, lead, and zinc) that are sometimes detected in water and sediment samples from the Eccles and Mud Creek drainages. Monitoring results from ongoing sampling will be checked to see if nickel values rise in the future. The mine has been working with the Utah Division of Water Quality and the Division to track nickel values.

#### Other Metals

Trace metals were below U. S. EPA maximum contaminant levels (MCL) in water samples collected from Mud and Eccles Creeks in 1979 through 1980 (Waddell and others, 1983b). Simons, Li, and Associates (1984) found the water at USGS gauging station 09318000, on Huntington Creek near the town of Huntington, met EPA drinking water standards.

Surface water quality data in the Skyline MRP show metal concentrations have generally met Utah Division of Water Quality criteria for class 1C, 2B, 3A, and 4 waters (The Utah Division of Water Quality revised the standards on February 16, 1994; to be based on dissolved metal concentrations, instead of acid-soluble metal concentrations). Dissolved selenium in water discharged from the Utah #2 Mine and monitored at VC-3 and VC-3a from 1973 to 1978 frequently exceeded the current Class 1C water quality standard of 0.01 mg/L and exceeded the Class 4 standard of 0.05 mg/L several times (Valley Camp, 1993, Appendix 722.100a).

There are no applicable standards for total metals in water, but what appear to be elevated concentrations of total copper (0.03 mg/L up to 24.5 mg/L) were found between 1981 and 1991 in samples from most of Skyline's sampling stations, including CS-7 and CS-10 in upper Huntington Canyon. High total lead (up to 0.74 mg/L) and total zinc (up to 0.062 mg/L) also were found in several samples (Coastal, 1993, Volume 4). Data from the White Oak Mine contain several analyses with similarly high total lead, copper, and zinc concentrations. The igneous dikes crossed during mining may be the source of these metals.

#### pH

The range of the average pH of surface water in the Mud Creek and Huntington Creek basins is 7.2 to 8.0 based on measurements at numerous locations. Extremes of 6.0 to 9.2 have been reported. Where both acidity and alkalinity have been determined, alkalinity is typically at least 25 times acidity.

### Solids

The estimated annual sediment yield of the Skyline permit area is approximately 0.44 acre-ft per square mile, which would indicate total annual yield to the Price River is 1.25 acre-ft and to the San Rafael River it is 3.07 acre-ft. The majority of this is suspended sediment, with only a small percentage carried as bed load (Coastal, 1993, p. PHC3-2). Using the same estimated yield of 0.44 acre-ft per square mile for the White Oak permit area, approximate total annual yield to the San Rafael drainage is 0.5 acre-ft and to the Price River drainage is 1.7 acre-ft.

Total suspended solids (TSS) measured at CS-3 and CS-11 in the headwaters of Eccles Creek averages 17 and 49 mg/L, respectively. Average TSS is 92 mg/L at station CS-6 on Eccles Creek, just above the confluence with Mud Creek. The maximum TSS at this location has been 3190 mg/L, and the minimum 1.4 mg/L. TSS averages 103 mg/L at VC-9, at the confluence with Mud Creek. The average TSS at VC-5 on Whisky Creek has been 454 mg/L, and the minimum 1.0 mg/L. Annual average TSS at VC-1 on Mud Creek below the White Oak Loadout is 183 mg/L.

Total suspended solids in Huntington Creek at station UPL-10, above Electric Lake, have varied from 1.4 to 3190 mg/L (May 1983), and averaged 87.6 mg/L from 1981 to 2005. Suspended sediment loads reported by the USGS for undisturbed areas of the Huntington Creek drainage are typically less than 100 mg/L at low flow, but during high flows can be between 500 mg/L and 1000 mg/L. In lower Huntington Creek, suspended sediment loads in excess of 10,000 mg/L can be expected from thunderstorms, and major floods could produce even higher levels. Construction, mining, and traffic on unpaved roads have produced increases in suspended sediment load in streams, but these are minor, temporary conditions that have not been quantified (Simons, Li, and Associates, 1984, p. 2.33).

The naturally reproducing population of cutthroat trout in Eccles Creek was virtually eliminated from Eccles Creek between 1975 and 1983 as road and mine construction increased the sediment load in the stream. Up to 18 inches of fine sediment had accumulated over the natural substrate. However, habitat improvement initiated in 1981 resulted in significant recovery of the trout population, totaling 93% of pre-disturbance levels by 1986 (Donaldson and Dalton, Utah Division of Wildlife Resources (DWR) in Appendix Volume A-3, Coastal States, 1993).

Landslides occurred at approximately 1500 locations in the Wasatch Plateau during the 1983-1984 water year, due to higher than average precipitation. One of these slides occurred in the North Fork of Eccles Canyon, where the creek is normally diverted beneath Skyline's topsoil stockpile. Debris blocked the entry to the diversion, water overtopped the stockpile, and mud and other debris were flushed into Eccles Creek. TSS was measured at up to 9800 mg/L in Eccles Creek by Division personnel. During this same period, mud was flowing into Whisky Creek from the unpaved road to the White Oak Mine. TSS levels were not documented in

Whisky Creek, but the deterioration of water quality from suspended solids was visibly evident to Division personnel who investigated.

In 1987, a tunnel was advanced through an igneous dike in the Skyline #3 Mine. A dark mica mineral, phlogopite, was carried from this tunnel to the sedimentation pond by the mine discharge water. The phlogopite did not settle-out in the pond and was discharged into Eccles Creek, where algae entrapped it. The phlogopite and algae, along with bacteria and mold, produced a marked discoloration of stream substrate, described as "slime", as far as the White Oak Loadout on Mud Creek. The fine sediment did not seem to be having any direct effect on the fish in July 1987, but macro invertebrates were substantially fewer in number and less diverse in Eccles Creek below the mine in comparison to Eccles Creek above the mine, South Fork, and Mud Creek. Elevated concentrations of nitrite, nitrate, and phosphate were found in water below the mine, and coliform bacteria in the sediment pond were elevated (UDWR, 1987).

Rerouting underground drainage around the dike, and adding a flocculent to the sedimentation pond solved the suspended phlogopite problem; but the slime was still in the streambed in late 1988 when sudsing was observed in Eccles Creek. Further water analyses found a surfactant in addition to continuing high levels of nitrogen and phosphorus. The source of the phlogopite was unrelated to that of these nutrients.

A survey of Eccles Creek in August and October 1989 by the Utah Division of Wildlife Resources (UDWR) found coal fines were accumulating behind beaver dams, particularly in the stretch downstream of the Skyline Mine, to the confluence with South Fork. Entrapment of the coal in the ponds was causing a loss of trout habitat in upper Eccles Creek, but it was also having a positive effect by preventing migration of the fines downstream to lower Eccles Creek, Mud Creek, and Scofield Reservoir. Fish were almost absent from Eccles Creek at the South Fork confluence, but downstream numbers of fish increased and young fish were evidence of successful spawning. In addition to coal fines, gravel chips from the highway had completely covered the substrate in places (Report dated June 26, 1990 by UDWR in Appendix Volume A-3, Coastal States, 1993).

Studies of macro invertebrates and sediment in Eccles Creek done for Skyline by Ecosystems Research Institute (ERI, 1992) found that the mean number of individuals, total number of taxa, and aquatic plant biomass decreased immediately below the mine and then increased downstream. Water below the mine was not acutely toxic, but the effects of chronic toxicity and sediment transport were not determined. The streambed immediately below the Skyline Mine was extremely embedded and 0.5 mm to 2 mm diameter particles made up approximately 15% to 25% of the sediment, compared to 5% to 10% in other reaches of the stream.

Benthic invertebrate studies conducted in Eccles Creek after the Skyline mine water discharge increased the streamflow to bankfull (Mt. Nebo Scientific 2005) show that the increased discharges were having a cumulative effect on the macro invertebrate populations. The October 2003 study (Mt. Nebo Scientific 2005) did show that there is an apparent trend

toward recovery, though far from where it needs to be. Skyline is required to repeat these benthic invertebrate studies in the spring and fall of 2006.

Winget (1980) noted that sheep and cattle grazing, recreation, unpaved roads, mines, and fires had all contributed to previous degradation and erosion of these watersheds. The results were increased sedimentation and reduction or loss of fish and invertebrate populations. Improved range management along Huntington Creek in the late 1970's allowed some recovery of riparian habitat and bank stability.

#### Nitrogen and Phosphorus

Wadell (1983a) concluded that Scofield Reservoir might become highly eutrophic unless measures are taken to limit the inflow of nutrients. Winget (1980) attributed nutrient input to Scofield Reservoir to recreation, cattle and sheep grazing, and domestic sources. Wadell's study during the 1979 and 1980 water years found that Mud Creek was providing 16% of the inflow to the reservoir but 18% of the total nitrogen and 24% of the total phosphorus. Wadell attributed elevated nutrient levels in 1979 and 1980 to the clearing of 27 acres of forested land for fire prevention around the Skyline Mine portals and roads in 1979.

Fish Creek and Mud Creeks account for 52 % and 29 % of the nutrient input to Scofield Reservoir, respectively. Obviously, Mud Creek contributes a disproportionately high amount of the nutrients compared to flow contribution. Total phosphorus in particular has been directly correlated with sediment load, and phosphorous loads in Scofield Reservoir have been directly attributed to the erosion and transport of soils during spring runoff. Peaks in nitrate and phosphate during spring runoff have been measured in Mud Creek (Clyde and others, 1981).

The Mud Creek drainage has nutrient-rich soils that are fairly erodable, but increased flows from the mine have not substantially changed stream morphology (EarthFax, 2002, 2003, and 2004), nor have they increased the total phosphorous in the reservoir (measured at MC-3; see Figure 12, Appendix A).

Inflows to Skyline Mine have been pumped into Eccles Creek since 1983. Since March 1999, inflows to Skyline Mine have been pumped to abandoned underground workings, allowed to settle, and then pumped to Eccles Creek. Discharges have been continuously recorded since August 16, 2001, and from then through September 2005, have varied from 0 to 10,500 gpm, with an average of about 5,666 gpm. The volume of water pumped to Eccles Creek (and subsequently Mud Creek, and Scofield Reservoir) as of September 2005, is 37,362 acre-ft. This has increased the average flow in Eccles Creek to about 3 times the normal average flow (pre-1999), and increased flow in Mud Creek to about 1.2 times the normal average flow. Flows are still only about 13% of spring runoff rates. Pumping was expected to decline to about 2,900 gpm in December 2004, but has not dropped below 4,000 gpm.

TSS and flow at sample locations CS6 on Eccles Creek, VC9 on Mud Creek, and VC1 on Mud Creek show that the average sediment yield carried by Eccles and Mud Creeks prior to 1999 was 2,710 Tons/yr. The average sediment yield carried by Eccles and Mud Creeks between 1999 and 2002 has been 2,908 Tons/yr, which is an increase of 7% annually.

Five new monitoring sites were added to Mud Creek and two on Eccles Creek to determine if the significantly increased mine discharge flows are having a negative impact on Mud Creek or Scofield Reservoir. These sites are monitored for total flow, TDS, TSS, and total phosphorous, and for changes to stream morphology.

There is no water quality standard for nitrite, but concentrations in excess of 0.06 mg/L produce mortality in cutthroat trout (UDWR, 1988). Nitrate should not exceed 10 mg/L in Class 1C water, and levels above 4 mg/L are considered an indicator of pollution, usually from sewage. Levels of phosphate in excess of 0.04 mg/L are not toxic to trout, but are excessive and promote eutrophication (UDWR, 1988). By state standards for Class 1C, 2A, 3A, and 3B waters, phosphate in excess of 0.05 mg/L is a pollution indicator. The recommended limit for MBAS, a surfactant, is 0.2 mg/L (Steve McNeil, Utah Dept. of Health, personal communication with the Division, 1988).

At station UPL-10, on Huntington Creek above Electric Lake, total nitrogen averaged 0.23 mg/L from July 1981 to June 2005, with highs of 1.0 mg/L ammonia and 0.68 mg/L nitrate and lows of <0.01, and <0.02 mg/L, respectively. Total phosphate averaged 0.040 mg/L with a high of 0.06 and a low of <0.01 mg/L. At UPL-3, just below Electric Lake, total nitrogen averaged 0.6 mg/L from 1981 to 1991, with highs of 1 mg/L as ammonia and 2 mg/L as nitrate and lows of 0 mg/L for both. Total phosphate averaged 0.2 mg/L with a high of 2 and a low of 0 mg/L (Coastal, 1993).

Data collected by Winget (1980) from 1976 to 1978 indicated that phosphate in Electric Lake was below the minimum concentration needed by aquatic life, and nitrate was just above the limit. These nutrient concentrations reflected the mesotrophic nature of the streams feeding the reservoir. Eccles Creek had nitrate concentration adequate for algal growth at most times, but low phosphate.

Discharge weighted average concentrations for nitrogen and phosphorus at Station S-29 in Eccles Canyon (same as USGS gauging station 09310600 and Skyline's station CS-6) during water years 1979-1980 were 11 and 2.2 mg/L. Concentrations of suspended and dissolved nitrogen combined reached 21 mg/L in May 1980, and phosphorus reached 4.3 mg/L. These nutrient levels apparently resulted from the clearing of 27 acres of forested land for fire prevention around the Skyline mine portals and roads in 1979 (Waddell et al., 1983a). In Mud Creek, downstream of the confluence with Eccles Creek, at S-36 (near Winter Quarters Canyon and USGS gauging station 09310700), discharge weighted average concentrations were 1.3 mg/L nitrogen and 0.1 mg/L phosphorus. The downstream decrease is attributed to the nutrients from Eccles Creek being mostly in suspended form that settles out in the slower flow of Mud

Creek. About 50% of the nitrogen and 25% of the phosphorus in Mud Creek in 1980 came from Eccles Creek, but only 20% of the flow. Concentrations of nutrients in Mud Creek peaked at about the same time as those in Eccles Creek (Waddell and others, 1983a; Waddell and others, 1983b).

At CS-6, on Eccles Creek, total nitrogen averaged 0.6 mg/L and phosphate averaged 0.14 mg/L between 1981 and 2002. Highs and lows for nitrogen were 2.5 and 0.01 mg/L nitrate and 3.5 and 0.01 mg/L ammonia; for phosphate they were 0.76 and 0.01 mg/L. Data from 1976 to 1979 from several stations along Eccles Creek indicate a high for nitrate of 2.70 mg/L and for phosphate of 0.22 mg/L (Vaughn Hansen Associates, 1979). High, low, and mean nitrate concentrations at VC-1 were 0.38 mg/L, 0.01 mg/L, and 0.07 mg/L between 1975 and 2002, but analyses for nitrates have been infrequent since 1988. Maximum phosphate was 4.55 mg/L in June 1984 and minimum was 0.01 mg/L in September 1987. No phosphate analyses have been done at VC-1 since 1999.

In 1987 a dark mica mineral, phlogopite, was being discharged from Skyline Mine #3 into Eccles Creek by way of the sediment pond (as discussed above). The phlogopite was entrapped in algae, which combined with bacteria and fungi to produce slime on the stream substrate as far as the White Oak Loadout on Mud Creek. The fine sediment did not seem to be having any direct effect on the fish in July 1987, but macro invertebrates were substantially fewer in number and less diverse in Eccles Creek below the mine in comparison to Eccles Creek above the mine, South Fork, and Mud Creek. Analyses of water samples taken by UDWR (Table 9) found 0.46 mg/L total nitrogen in the stream below the Skyline Mine, 0.11 mg/L nitrite (24% of total nitrogen), and 0.34 mg/L nitrate (76% of total nitrogen). Total nitrogen measured above the mines, was 0.29 mg/L, with no nitrite. Phosphate levels in the Skyline sediment pond and Eccles Creek were 0.045 mg/L, but no phosphate was detected above the mine. UDWR subsequently found elevated total, and fecal coliform bacteria in the sediment pond. Because of the bacteria and nitrites, UDWR suspected that the sewage tank was backing up into manhole connections, and leaking into the sediment pond. UDWR recommended chlorination of the sediment pond, and other procedures to avoid recurrence of the suspected sewage backup (UDWR, 1987).

**TABLE 9**

	Nitrite	Nitrate	Ammonia	Organic Nitrogen	Phosphorus Total	MBAS Detergent
Sampled by UDWR July 1987 (UDWR, 1987)						
Above Skyline Mine	not detected	0.29	**	**	not detected	**
Below Skyline Mine	0.11	0.34	**	**	0.045	**

\*\* Analysis not reported, probably not done

The phlogopite was eliminated from the pond discharge by rerouting flow in the mine, and using a flocculent. The UDWR recommendations for reducing pollution from sewage were also implemented, but slime persisted in the streambed through the summer of 1988. Random checks by UDWR indicated that the water quality was acceptable. Fish were abundant, and macro invertebrate populations appeared normal in lower Eccles Creek, however in late September of 1988, foaming was observed in Eccles and Mud Creeks along the same reaches where the slime was found. The slime appeared to be covering more surface area, and extending deeper into the substrate. Division personnel took water samples on Eccles Creek above and below the mines in September and October 1988 at several locations within the 72-inch bypass culvert, including at the discharge of the sedimentation pond (Table 10). Analysis of these samples revealed that high nitrite levels persisted. In September, nitrite concentration was 0.64 mg/L in the outfall of the 72-inch culvert, which carries undisturbed drainage beneath the disturbed area, and also receives the discharge from the sedimentation pond. Ammonia and organic nitrogen concentrations were also elevated in comparison to undisturbed drainage (The Division, 1988). Samples taken from the pond outfall by UDWR in October 1988 had 14mg/L nitrate and 0.09 mg/L nitrite (UDWR, 1988). Results of analyses from several different sources during September and October are summarized in Table 10.

Total phosphate was 0.50 mg/L in one sample of the discharge from the Skyline shop (Utah Fuel Company, 1988). Another sample from the shop sump reportedly approached 13 mg/L (Keith Zobell, personal communication, The Division, 1988). Samples taken from the sedimentation pond by UDWR personnel in July and October of 1988 had phosphate levels of 0.045 mg/L and 0.06 mg/L (UDWR, 1988). Water analyses also detected a detergent, MBAS, in the sediment pond, and in the outfall (Table 10)

In addition to the laboratory analyses, Skyline used a field kit to check nitrate levels at various times and locations. On October 5, 1988, nitrate levels were 8 to 9 mg/L in Eccles Creek below the mine and 13 mg/L in the discharge from the #3 mine. Other flows into the sediment pond showed no nitrate, indicating that the sewage holding tanks were not the source of the nitrate. On October 6, water coming off the longwall section of the #3 mine had 5mg/L nitrate, return water had 3 mg/L, and overflow from the emulsion pump had 2 mg/L. Water from mined out areas had no nitrate (Utah Fuel Company, 1988).

Trout and invertebrates had not been checked in upper Eccles Creek in mid-September 1988 when lower Eccles Creek was monitored, because lower Eccles Creek was supporting healthy populations even with the slime present. However, an intensive sampling of fish and macro invertebrate populations in early October 1988 revealed that the trout population and biomass in upper Eccles Creek had declined over 90%. Macroinvertebrates were essentially gone in upper Eccles Creek downstream from the sediment pond outfall, but taxa and numbers increased downstream, as did numbers and biomass of fish. High concentrations of nutrients were producing both toxic and eutrophic conditions. Nitrite in the water was a contributing and probable primary cause of mortality of macroinvertebrates in upper Eccles Creek and had forced trout to migrate downstream to where dilution produced a tolerable habitat. Trout spawning had

not been successful in 1987 and 1988 in any section of the stream: either the slime precluded successful spawning, the nitrites were fatal to the eggs and fry, or both (UDWR, 1988). Refer to the section Fish and Invertebrates for more information.

**TABLE 10**

	Nitrite	Nitrate	Ammonia	Organic Nitrogen	Phosphorus Total	MBAS Detergent
Sampled by UDWR July 1988 (UDWR, 1988)						
Sed. Pond Effluent	**	**	**	**	0.045	**
Sampled by the Division 28 September, 1988						
North Fork	<0.05	1.20	<0.05	<1.00	<0.05	<0.03
Middle Fork	<0.05	0.59	<0.05	<1.00	<0.05	<0.03
South Fork	<0.05	0.21	<0.05	<1.00	<0.05	<0.03
72" Bypass Outfall	0.64	0.38	0.19	1.30	<0.05	0.28
Sampled by the Division 03 October, 1988						
Sed. Pond at 3'	*	0.26	0.14	*	<0.05	0.75
Sed. Pond at 6'	*	0.37	0.14	*	<0.05	0.50
Sed. Pond at 9'	*	0.32	0.14	*	<0.05	0.83
Sed. Pond at 10.5'	*	0.3	0.16	*	<0.05	*
72" Bypass Outfall	*	0.33	0.25	*	<0.05	*
Pond Spillway in Bypass	*	0.41	0.18	*	<0.05	0.80
Middle and South Fork Confluence in Bypass	*	0.25	*	*	<0.05	0.1
28" Pipe in Bypass	*	*	*	*	<0.05	0.09
Sampled by UDWR October 1988 (UDWR, 1988)						
Sed. Pond Effluent	0.09	14.0	**	**	0.06	**
Sampled by Skyline October 1988 (Utah Fuel Company, 1988)						
Eccles Creek	**	**	**	**	0.04	***0.90
Mine #3 Discharge	0.08	2.28	**	**	0.04	***0.87
Sed. Pond Discharge	0.04	3.39	**	**	0.06 and 0.04	***1.33
Shop Discharge	0.03	3.18	**	**	0.50 and 0.36	***1.33

\* Analysis not done

\*\* Analysis not reported, probably not done

\*\*\* Unspecified surfactant, not identified as MBAS



**WATER QUALITY**

Mud Creek &amp; Upper Huntington

Elevated nitrites were traced to emulsion oil used in the longwall system in the #3 mine. In the 1:20 dilution that was used at the time, nitrite concentration was 182 mg/L and nitrate was 872 mg/L. As much as 4000 gallons of this emulsion was released each time the longwall unit was moved, which had occurred six times from 1986 to 1988. There were also occasional spills and leaks when the longwall operated. The oil was captured and removed from the water by skimming, and flocculation before it left the mine, but the nitrogen compounds went into solution in the water and passed through the sediment pond into Eccles Creek. Skyline replaced the emulsion oil with one that contained no nitrites or nitrates as soon as the connection was realized. Field kit test results submitted to the Division by Skyline in late 1988 indicated that the nitrate and nitrite levels were dropping in discharges from Mine #3 and the sediment pond (Utah Fuel Company, 1988). Samples taken by the Division in December 1988 (Table 11) detected no nitrite or nitrate in discharges from the #3 mine, or the pond; but elevated levels were found in the discharge from the #1 mine. Field kit results from January to May 1989 showed consistent nitrite and nitrate levels, 0.03 mg/L and 1.07 mg/L respectively, in both the sediment pond and the Mine #3 discharge. In 1989 the longwall unit was moved from Mine #3 to Mine #1. Nitrate and nitrite were within acceptable limits by August 1989 (Table 11).

Sudsing and elevated phosphate turned out to be unrelated to the nitrogen compounds, and were caused by detergents used in the shop and offices. Mop water was being disposed of into floor drains, which empty into the 72-inch bypass culvert by way of the sedimentation pond. Skyline has solved the problem by replacing detergents with low sudsing, non-phosphate types and revising procedures so that mop water is now discarded into the sanitary sewer (Utah Fuel Company, 1988).

**TABLE 11**

Sampled by the Division	Nitrite				Nitrate			
	12/14/88	3/29/89	4/18/89	8/31/89	12/14/88	3/29/89	4/18/89	8/31/89
Mine #1 Discharge	0.83	?	*	0.05	5.2	0.034	*	0.075
Mine #3 Discharge	<0.05	0.013	0.14	*	<0.05	0.039	2.0	*
Pond Discharge	<0.05	0.032	0.24	<0.05	<0.05	0.033	1.76	1.48
72" Bypass Outfall	*	*	<0.05	<0.05	*	*	<0.05	1.11

\* Analysis was not done

### Oil and Grease

There is no water quality standard for oil and grease, but the UPDES permit limit for both the White Oak and Skyline Mines is 10 mg/L. However, a 10 mg/L oil and grease limit does not protect fish and benthic organisms from soluble oils, such as those used in longwall hydraulic systems. The UDWR has recommended soluble oils be limited to 1 mg/L (Darrell H. Nish, Acting Director UDWR, letter dated April 17, 1989 to Dianne R. Nielsen, Director of the Division). For water being discharged to Electric Lake from the JC wells, the limit is also 10 mg/L.

Oil and grease in water discharged from Skyline Mine #1 (CS-14) averaged 2.5 mg/L from January 1989 to August 2005, with a maximum of 23.4 mg/L measured in June of 1993. The average oil and grease at Mine #3 (CS-12) from November 1983 to June 2005 was 1.6 mg/L, with a maximum of 12.5 mg/L, recorded in 1987. Discharge from the sediment pond has only occasionally (10 of 297 sample) exceeded the 10 mg/L UPDES limit (3 times in the 1980's, 6 times in the early 1990's, and once in 2002).

The principal source of oil discharged from Mine #3 appears to be the longwall unit that was installed in 1986. A water-oil emulsion (5% oil) is used in the longwall hydraulic system to meet MSHA fire protection requirements. As much as 4000 gallons of this emulsion can be released each time the longwall unit is moved. The unit was moved six times between 1986 and October 1988. There are also occasional spills and leaks when the longwall is operating. Oil is captured and removed from the mine water discharge system by skimming and flocculation before it leaves the mine. Since 1988 an extensive no-spill program has been part of the longwall operations, and if a spill does occur the water and oil emulsion is to be pumped into abandoned sections of the mine rather than being discharged to the surface (Utah Fuel Company, 1988). If there is flocculated oil in the sediment pond sludge, it is a potential source of recontamination that will eventually require proper removal and disposal.

Although Well JC-3 discharged water directly from the mine workings, it was pumped from a portion of the mine that is flooded and not accessible. No evidence of contact with oil & grease, emulsion fluids, or any other contaminants was ever measured.

Prior to 1985, oil and grease in water discharged from the White Oak Mine was generally less than 0.5 mg/L, with a maximum of 2.2 mg/L. Between September 1985 and June 1989, measurements exceeding 0.5 mg/L increased, and the February 21, 1986 sample exceeded 10 mg/L. Longwall mining equipment was never used in the White Oak Mine. Reasons for the increase in oil and grease in the mine discharge have not been identified.

### Temperature

Water temperatures in the streams fluctuate greatly, because low flows and turbulence act to quickly equilibrate water temperatures with air temperatures. Winget (1980) found daily fluctuations of 12 to 15° C during warmer months, but fairly constant temperatures (0 to 2° C) from November to March. The Division found that the temperature of Eccles Creek increased,

from 43° F to 54° F, as it passed through the 72 inch bypass culvert and joined with the sediment pond discharge (The Division, 1988). Since the streams within the CIA have steep gradients and rocky beds, entrainment of air and transfer of oxygen, and equilibration with air temperature should be sufficient to eliminate temperature as a factor in habitat quality.

The maximum allowable temperature change for Class 3A waters is 2° C (3.6° F). The water temperature of the combined discharges of the JC wells is approximately 14°C. Since the temperature of the receiving waters, Electric Lake, varies from 0.5° - 19.7°C at the surface (winter to summer, respectively) the temperature of the discharge is satisfactory.

#### Fish and Invertebrates

Upper Huntington and Eccles Creeks have naturally reproducing populations of cutthroat trout. Rainbow and brown trout were reported in upper Huntington Creek prior to 1979, but UDWR's work to eliminate these trout species from this fishery has apparently been successful. Rainbow trout have been planted in Scofield Reservoir, and cutthroat trout are recruited from inflowing streams. Speckled dace, mountain suckers, and mottled sculpin are also found in area streams. Macroinvertebrate communities in both drainages have considerable species diversity (Winget, 1980).

#### *James Creek*

The Skyline Mine MRP (page 2-71) commits to conducting macroinvertebrate studies and fish studies in James Creek for 2 years beginning in October 2001 and then every three years thereafter. Sampling should identify any slow degradation of the creek due to sedimentation. Unfortunately, only one year of baseline data was obtained prior to mining activities. Mt. Nebo Scientific, Inc. collected the data for the first two years, and Dr. Dennis Shiozawa conducted the surveys. The October 17, 2000 and 2001 (2001 Annual Report) reports found James Creek to be in excellent condition despite the large decrease in macroinvertebrate and fish numbers, Table 12 summarizes the sampling.

**TABLE 12. Summary of Aquatic Resource Sampling on James Creek in 2000 and 2001.**

<b>Date</b>	<b>Macroinvertebrate #/m<sup>2</sup></b>	<b>Biomass (g/m<sup>2</sup>)</b>	<b>Total Fish</b>
Fall 2000	378,510*	272	587
Spring 2001**	335,000		
Fall 2001	127,875	256	93

\*Used summary data from Fall 2001 report, because Fall 2000 report indicates 34,757/m<sup>2</sup>.

\*\* Spring 2001 report not found; used summary data from Fall 2001 report.

The 2001 report provides several explanations for the decrease in macroinvertebrate and fish numbers, and cannot directly attribute the decrease to mining activities. The large amount of drilling fluids that spilled into the Creek while drilling the James Canyon Wells was not mentioned, or accounted for in this study. However, a subsequent conversation between Susan White of the Division and Dr. Shiozawa indicated that the drilling fluids could have influenced the fish numbers. The James Canyon well drilling was carried out under an exploration permit administered by the BLM.

Because of the lack of adequate baseline data, and the dramatic decrease in numbers of macros and fish for Fall 2001, studies are ongoing in James and Burnout Creeks. The Spring 2002 report concluded, "Both streams can be considered to be in good condition. The impact recorded in the fall of 2001 in James Canyon appears to have been temporary."

### *Eccles Creek*

UDWR ranks Eccles Creek as a valuable trout stream, mainly as a spawning stream for wild cutthroat trout that are eventually harvested in Scofield Reservoir. Data the UDWR collected in 1971, prior to coal development, identified Eccles Creek as a somewhat pristine fishery. The stream sustained an estimated 1,272 wild cutthroat trout along 2.5 miles of habitable stream. Adult trout comprised only 4% of this population (Donaldson and Dalton). Although not officially documented by UDWR, local sportsmen have reported catching 'some of the largest cutthroat out of Eccles Creek' that they have seen out of any stream on the Wasatch Plateau. This is attributed to the increased flows in Eccles Creek due to the increased mine discharge observed beginning in August 2001.

Benthic invertebrate studies were done by the USGS at three sites on Mud Creek and two in Eccles Canyon in July and September 1979, and July and October 1980. There were consistent downstream and seasonal trends. Diversity decreased downstream in Eccles Canyon, probably because Skyline Mine was relocating the stream at the time (Waddell and others, 1983b).

Winget (1980) collected data on invertebrates and sediments in Eccles and Huntington Creeks prior to construction of the Skyline Mine. Skyline studied benthic communities and sediment composition of gravel beds in Eccles Creek from 1979 to 1985. Fishery habitat studies were also done (Coastal, 1993, p. 2-70).

In conjunction with the Skyline study, UDWR conducted fish surveys the first week of August from 1979 to 1986 (Donaldson and Dalton). UDWR found that the fishery began to decline after 1975 in the 1.75 mile stretch of Eccles Creek below the turnoff to the White Oak Mine. The construction of roads and mines caused high sedimentation in the stream, depositing up to 18 inches of fine sediment above the natural substrate. In 1979, the fish population along the entire 2.5 miles of habitable stream was down to 40% of 1971 pre-mining levels, and 18% of the fish were adults compared to 4% in 1971. Construction of the Skyline Mine began in 1980. Mitigation started in 1981, but deterioration of the stream continued. By 1983, most of the road through Eccles Canyon was asphalted, and disturbed areas were revegetating. Still, only 27 fish

were found in Eccles Creek, a 98% reduction compared to 1971. There were no young-of-year or 1-year juveniles. A reduction of sedimentation was evident by 1985, and by 1986 the cutthroat population had recovered to 93% of the 1971 levels and 1-year juveniles were present (Donaldson and Dalton).

The UDWR conducted fish surveys and macroinvertebrate inventories in 1988 as part of the investigation of the problems with foam and slime in Eccles Creek (discussed above). Fish population had been estimated in 1986 to be 600 fish per mile. In mid September 1988, fish in lower Eccles Creek were abundant and macroinvertebrate populations appeared normal. However, when Upper Eccles Creek was assessed in October 1988, only 20 fish per mile were found. It was also found that one and two-year old fish were absent from the population. Macroinvertebrate diversity dropped from 6 - 7 families per square foot above the Skyline Mine, to 1 family present below the mines. Diversity in Mud Creek was 8. Toxicity from nitrites and eutrophication from nitrates and phosphates were the causes of these population losses (UDWR, 1988; The Division, 1988).

R. W. Baumann (1985) and Ecosystems Research Institute (ERI, 1992) performed studies of macroinvertebrates and sediment in Eccles Creek for Skyline. Benthic invertebrates in the stream below the mines indicated stress in the 1984 - 1985 surveys, but showed recovery from the conditions that existed in 1981. In 1991, mean number of individuals, total number of taxa, and aquatic plant biomass decreased immediately below the mine; then increased further downstream. The zone of impact appeared to extend to the confluence of Eccles Creek with Mud Creek, but parameters there were similar to those in Mud Creek. It was determined that the water below the mine was not acutely toxic, but the effects of chronic toxicity and sediment transport were not determined. The streambed immediately below the mine was extremely embedded, and the percentage of sediment 0.5 to 2 mm in size was significantly higher than elsewhere in the streams. Electrical conductivity of the water was highest directly below the mine and decreased further downstream. Sulfate leached from rock dust in flooded, abandoned areas of the mine has been identified as the reason TDS levels in mine water discharges were exceeding UPDES standards.

#### *Upper Huntington Creek*

After the spillway gates of Electric Lake were closed in 1973, and the reservoir began to fill, UDWR measured increasing numbers of cutthroat trout in Huntington Creek above the lake. Numbers increased from 104 fish per 0.1 mile in 1974 to 263 fish per 0.1 mile in 1977. Also, smaller fish made up increasing percentages of this population, indicating increased reproduction, resident fish, and increasing recruitment stock for the reservoir (Winget, 1980).

Benthic invertebrate studies were done by the USGS at seven sites in Huntington Creek from 1977 through 1979. Diversity indices had a large variability that was attributed to variations, possibly natural, in water quality and stream environment. Simons, Li, and Associates (1984) concluded several years worth of additional data would be required to establish baseline conditions.

### *Winter Quarters Creek*

Winter Quarters Creek was surveyed by UDWR in 1968 and 1971. In 1968, 70 cutthroat trout were found along a 0.1 mile reach, with a maximum size of 14 inches. Winget (1980) does not report the numbers for 1971, but maximum size was 9 inches and the presence of young fish indicated successful spawning. Banks were stable along 70% of the stream. Spawning gravels composed 38-42% of the substrate, but low flows limited fish production. Caddisflies, stoneflies, and mayflies were common and water quality was high (Winget, 1980).

### **Stream Channel Alteration, Alluvial Valley Floor, and Land Use**

The Division's March 1984 Technical Analysis written for the Valley Camp Mine (now the White Oak Mine) provides a summation of the history of the alluvial valley floor determination. The Division stated that Whisky Canyon and Pleasant Valley (above the Utah #2 facilities) were observed by the Office of Surface Mining in August of 1983 to be too narrow for flood irrigation or subirrigation agricultural activities. Also in 1984, it was noted that the pastures are flood irrigated and the grasses on the valley bottom may be subirrigated.

Since August 2001, Skyline Mine has been discharging an average of 5,666 gpm (12.6 cfs) into Eccles Creek. These waters flow down Eccles Creek and then to Mud Creek. Mud Creek flows through Pleasant Valley, which is an alluvial valley floor below the Utah #2 Mine. This flow has *increased* water availability in, and has not caused material damage to the quality of, water supplying the alluvial valley floor.

The historical record of flow in Mud Creek is graphed in Figure 2.12.C of the Skyline Mine MRP, as recorded at the USGS station just downstream of the confluence with Winter Quarter's Creek. Ordinarily, high flows of approximately 100 – 150 cfs occur for a short duration during the months of May and June. Flows quickly subside after snow melt, back to the baseline flow of approximately 6 – 12 cfs. The highest daily mean flow during the period from 1974 – 2005 was 384 cfs during the month of May 1984. The lowest daily mean flow was 1.6 cfs during January 1980. The mine discharge is constantly contributing additional water to the baseline flow.

Measurements of flows taken on November 26, 2001 (Appendix D, Skyline Mine MRP) recorded 18.4 cfs in Mud Creek after the confluence with Eccles Creek and 24.44 cfs after the confluence with Winter Quarters Creek. The gain in flow downstream is attributed to contributions from springs and side streams (2 – 3 cfs) and re-emerging baseflow from the alluvium of 3 – 4 cfs (Section 2.12 and Appendix D July 2002 Addendum to the Skyline Mine PHC).

The mine waters being discharged to Eccles Creek had an average Total Dissolved Solids (TDS) level of 600 mg/L in July of 2000. Currently (Oct. 2005), the Eccles Creek mine discharge water has an average TDS of 850-950 mg/L. In Eccles Creek above the mine, the average concentration of TDS is 300 mg/L (July 2002 Addendum to the PHC).

As part of the alluvial valley floor determination, cross sections of the Mud Creek channel were measured at six different stations. The potentiometric surface was measured at four of those stations. At Station 7300, in the vicinity of Green Canyon, the groundwater is four feet below the surface. In the area of Station 14480, the groundwater level is eight feet below the surface, reflecting the rolling nature of the land and the incised nature of the stream channel. The ground water rises back up to four feet below the surface at Station 17340. Station 17340 is located at the site of an irrigation diversion; so as a result, the depth to groundwater at a point 400 feet distant from the stream is closer to the surface than that along the stream channel. This is due to irrigation return flow as well as stream channel entrenchment (Section 2.12 of the Skyline Mine MRP).

The land along Mud Creek is owned by four different landowners, and is used for grazing. Ray Jensen, Range Specialist for the Bureau of Land Management (BLM) describes the area as sub-irrigated, grazed land with an historical yield of 4000-6000 pounds/acre. The predominant vegetation type is grass. The number of animals grazed on the pastures by each landowner is variable with time.

Canyon Fuel Company has evaluated the value of the pasture ground in terms of the replacement cost for feed. At a consumption rate of 0.5 tons per month, and a cost of \$100 per ton of hay; the replacement cost is \$50 per animal per month. The need for replacement of feed is not likely, however, since grazing will not be impeded by high flows along Mud Creek, and the reduction in available grazing area is limited to stream banks that may be eroded by the high water.

Dr. Patrick Collins of Mt. Nebo Scientific assessed the vegetation along the Mud Creek stream channel in December 2001 (Appendix A of Appendix D, July 2002 Addendum to the Skyline Mine PHC). He conducted a level II investigation using the methods of the USDA Forest Service. Two reaches were located on Mud Creek. Reach #4 is located just below the confluence of Eccles and Mud Creeks. The riparian community was approximately 91 feet wide and consisted of willows, sedge and rush grasses. Approximately 80% of the banks were vegetated and stable. Downstream, at Reach #5, the width of the riparian community broadened to 120 feet and consisted mostly of willows growing in both riparian and wetland communities. Approximately 60% of the bank was vegetated and stable (February 27, 2002, EarthFax report in Appendix D of the July 2002 Addendum to the PHC). Additional fieldwork observations were conducted in the summers of 2002 and 2003. The results of these observations did not provide any definitive alteration of the riparian or wetland communities.

The gradient of Mud Creek is approximately 0.0091 ft/ft with a sinuosity ratio of 1.6. These figures were derived from aerial photographs (personal communication, November 15, 2002, Rich White, Earth Fax Engineering, with Priscilla Burton of the Division). The channel flattens on approach to Scofield Reservoir with an average gradient of 0.02 to 0.1 ft/ft. Channel subsoils are silty sands and clayey silts, classified by the 1988 Carbon County Soil Survey as Silas and Silas Brycan series. The results of laboratory analysis on the physical properties of the

soils in the creek are found in Appendix B of Appendix D of the July 2002 Addendum to the Skyline Mine PHC. Cross sections of the channel describe a channel bed that is 96% cobbles and gravels and side slopes that are 100% sand, silt and clay (Appendix E of Appendix D of the July 2002 Addendum to the Skyline Mine PHC). Low flow terraces are limited in extent and the channel is incised. There is no broad flood plain.

The current streamflows do not approach natural bankfull discharge (Table 5 of Appendix D July 2002 Addendum to the Skyline Mine PHC). The erosional stability of the Mud Creek channel beds and banks was evaluated and found to fall within the allowable velocity using the techniques of evaluation described by the Soil Conservation Service (Table 3 of Appendix D July 2002 Addendum to the Skyline Mine PHC).

A stability evaluation of the channel concluded that well vegetated slopes (grasses and willows) are able to handle the increased flow without erosion (Appendix D of the July 2002 Addendum to the Skyline Mine PHC). There are channel banks of Mud Creek that are not well vegetated and the landowners of these lands should avail themselves of programs that would provide assistance to armor the bank and divert flow to allow the eroding banks an opportunity to reclaim. In an effort to stabilize the stream bank in critical areas and prevent erosion before it began, Canyon Fuel Company obtained a stream alteration permit from the Division of Water Rights and planted trees in 22 locations along the stream bank in cooperation with the landowner.

The July 2002 Addendum to the Skyline Mine PHC (page PHC A-21) commits to armoring stream channel banks, planting of stream bank stabilizing vegetation, or redirection of some flows; should monitoring reveal that deterioration of stream chemistry or stream morphology or vegetative community is related to mine water discharge. To help mitigate any potential erosion of the stream banks in Mud Creek, Canyon Fuel Company has provided time and materials to a private landowner owning land on Mud Creek to establish additional armoring along the steeper cut banks located along the creek.

In conclusion, the potential negative impact to Mud Creek from the increased flows is not the interruption of agricultural activity, but the acceleration of instability in the channel banks and increased erosion of the stream channel in reaches of the channel that are not well vegetated. The area impacted would be very small in relation to the acreage being pastured and would be negligible to the total production of the pastures.

Stations along Mud Creek will be monitored four times a year (seasonally) for a period of one year following a reduction in mine discharge to 350 gpm or less. Sediment loading in Mud Creek will be computed from the TSS and flow data collected. Annual evaluations of the stream will be summarized in a report to be submitted to the Division with the Skyline Mine Annual Report. The monitoring plan will also evaluate the changes in stream morphology and vegetation at the stations over the same time period.



## **Ground Water - Baseline Conditions**

### Ground Water Quality - General

With few exceptions, ground water in the CIA is a calcium bicarbonate type. Spring water is generally of better quality than well or mine discharge water. Quality is usually highest in the second quarter of the year when flows are greatest. Samples are rarely taken during the first quarter because of snow cover. For the Waste Rock Disposal Site well (WRDS 1), water quality data are available for only one year, from October 1993 to October 1994. The WRDS wells have been dry at all other samplings. Locations of seeps and springs sampled for the Skyline and White Oak Mines are shown on Figure 5 (Appendix A). The Division feels these sampling locations adequately characterize the hydrologic regime.

The USGS analyzed water from 140 springs in the Huntington and Cottonwood Creek basins between July 1977 and September 1980. None of the analyses found concentrations over U. S. EPA drinking water standards (Engineering-Science, 1984, p. 2.39). Total dissolved solids content of the ground water from springs and seeps ranges from less than 125 mg/L in the Skyline permit area to 4000 mg/L at the confluence of the Price and San Rafael Rivers with the Green River.

### Ground Water Quality - Castlegate Sandstone

Spring S10-1, which is the only monitored spring that discharges from the Castlegate, or near the Castlegate-Blackhawk contact, has had an average TDS concentration of 99 mg/L, and a maximum of only 165 mg/L. This low TDS is attributed to the lack of shale in the Castlegate. The water is low in nutrients and metals. The pH averages 7.3 and alkalinity is typically 25 times acidity. Total and dissolved iron average 0.28 and 0.08 mg/L and total and dissolved manganese average 0.04 and 0.06 mg/L. Springs issuing from the Castlegate Sandstone typically have less than 180 mg/L TDS (Engineering-Science, 1984, p. 27).

### Ground Water Quality - Blackhawk and Star Point Formations

#### *Total Dissolved Solids (TDS)*

Springs and seeps monitored for the White Oak Mine typically have TDS values in the range of 200 to 300 mg/L. Quarterly average values go from a low of 96 mg/L in the second quarter at S25-13 to a high of 363 mg/L during the fourth quarter at S24-12. The highest TDS reported is 9187 mg/L at S36-19.

Skyline's data show that spring waters from perched aquifers in the Blackhawk Formation typically have TDS levels of 240 mg/L (Coastal, 1993, p. PHC2-6). The highest TDS is 646 mg/L at S13-2 in the north fork of Eccles Creek near the mine. Average TDS at this spring is 347 mg/L. High TDS is also found at S17-2, next to Eccles Creek just above the Skyline Loadout and at S24-12 at the head of South Fork.

Water discharged from the White Oak Mine and well water from the Blackhawk-Star Point aquifer had TDS levels of 180 to 480 mg/L in 1979 (Engineering-Science, 1984, Table 1). Average TDS in water discharged from the White Oak Mine from 1981 to 2000 was 674 mg/L, but TDS values as high as 1340 mg/L were measured (Valley Camp, 1993, p. 700-22).

Water discharged from the Skyline Mine contained an average of 467 mg/L TDS in 1984, but this had increased to an average of 1273 mg/L in 1991. The average had reduced to 520 mg/L in 2001, and then rose to 850 to 950 mg/L in late 2004. Average sulfate levels went from 150 mg/L in 1984, to 673 mg/L in 1991, and down to 162 in 2001. TDS in the waste-rock-disposal-site monitoring-well averaged 552 mg/L in 1992-1993.

#### *Iron and Manganese*

Waddell (1982) measured dissolved iron concentrations of 0.720 mg/L at the Clear Creek Mine. At the spring near the mouth of Eccles Canyon, which is the same as Skyline's S17-2, Waddell measured 0.860 mg/L. Skyline's twenty-seven measurements of dissolved iron at S17-2 between 1981 and 2004 averaged 0.38 mg/L. Both of these ground water sources issue from faults or fractures in the Star Point Sandstone.

For spring waters from perched aquifers in the Blackhawk Formation, total and dissolved iron average 0.71 and 0.10 mg/L, respectively, and total and dissolved manganese both average 0.02 mg/L.

In water discharged from the Skyline Mine, total and dissolved iron averaged 1.4 and 0.09 mg/L, respectively. Total and dissolved manganese levels averaged 0.1 and 0.07 mg/L at the No. 1 mine and 0.07 and 0.08 mg/L at the No. 3 mine. Water from wells is generally similar to mine discharge water (Engineering-Science, 1984, p. 27). At the waste rock disposal site, water from the monitoring well averaged 0.540 mg/L total iron and 0.048 mg/L total manganese in the four samples taken in 1992-1993 (1993 Annual Report).

Water discharged from the White Oak Mine between 1981 and 1989 contained an average total iron concentration of 0.56 mg/L. Total iron exceeded 1.0 mg/L 25 times from 1981 to 1985, with a maximum of 4.60 mg/L, but from 1985 to 1989 levels exceeded 1.0 mg/L only 3 times and the maximum for that period was 2.2 mg/L. From 1989 through 2000, Total iron exceeded 1.0 mg/L/day 6 times with the last exceedance in April 1998 being the highest reported value of 7.27 mg/L. From 1985 through 2000 the 30-day maximum of 70 mg/L Total Iron was exceeded 6 times, with the maximum being 155 mg/L in April 1985 and the last being 108 mg/L in May 1997.

#### *Other Metals*

Dissolved copper exceeded the 1 hour average criterion for Class 3A waters in the four samples from the monitoring well at Skyline's waste rock disposal site (1993 Annual Report). There are no applicable standards for total metals in water, but what appear to be elevated

concentrations of total copper, up to 0.42 mg/L, were found between 1981 and 1991 in the springs sampled by Skyline. Total lead up to 0.05 mg/L and total zinc up to 0.185 mg/L were also found (Coastal, 1993, Volume 4). Data from the White Oak Mine show concentrations of total lead up to 0.17 mg/L and of total zinc up to 0.135 mg/L, however, total copper values are all 0.02 mg/L or lower. Analyses were not done for dissolved copper, lead, and zinc (Valley Camp, 1993, Appendix 722.100a). The igneous dikes in the area may be the source of these metals.

To monitor the addition of mine-water discharge from JC-3 into Electric Lake, trivalent arsenic, cadmium, trivalent chromium, copper, iron, lead, mercury, nickel, selenium, silver, and zinc were to be monitored in both the effluent discharge into the lake and Electric Lake itself for a period of two (2) years. This will continue if the pumping resumes, to provide adequate baseline information, and ensure no degradation of Electric Lake is occurring.

### *pH*

The average pH range of ground water from monitored seeps and springs in the Mud Creek and Huntington Creek basins is 7.1 to 8.0, based on measurements at numerous locations. Extremes of 6.0 to 9.5 have been reported. Where both acidity and alkalinity have been determined, alkalinity is typically at least 25 times acidity (Coastal, 1993, p. PHC2-6).

The average pH of water discharged from the Skyline Mine (1983-2005) is 7.5 with a high of 9.0 in May of 1987 and a low of 6.5 in September 1989 (Division's Coal Water Quality Database). Water discharged from the White Oak Mine had an average pH of 7.7, with measured high and low of 9.7 and 6.7 (Valley Camp, 1993). The average pH measured at the Skyline Mine waste rock disposal site was 6.6 in 1992-1993, ranging from 6.51 to 6.84 (1993 Annual Report). The UPDES permit for Well JC-3 does not allow for it to change the average pH of water being discharged to Electric Lake. During its short operation time the average pH at JC-3 was 7.6. The average pH at the JC-1 well has been 7.8 (Division's Coal Water Quality Database).

### *Temperature*

Temperature variances become a potentially significant parameter when comparing potential sources of water. As outlined in Appendix G of the October 2002 Addendum to the PHC, water encountered in in-mine roof sources have been 8.9 °C, while the temperature of water extracted from Well JC-1 and originating below the mine in the Star Point Sandstone has a temperature range of 13.2 to 15.6 °C. The temperature from JC-1 suggests a source at-depth (geothermal gradient) necessary to produce the temperatures.

### *Dissolved Oxygen*

Although not typically analyzed in groundwater samples, dissolved oxygen has been useful in characterizing differences between water encountered within the mine and Electric

Lake water. The dissolved oxygen content of Electric Lake water is over 10 times greater than that of mine inflow waters. While dissolved oxygen can be readily removed from groundwater, it seems unlikely that would occur while moving large volumes of water rapidly through fractures, as some have hypothesized.

### **Ground Water Quantity – Baseline Conditions**

Flow of springs and seeps issuing from the perched aquifers varies seasonally, indicating local systems. Recharge for most of these springs and seeps probably originates in the small surface depressions or basins in the immediate vicinity. Higher flows occur during spring snowmelt, and flows in the autumn are often lower by an order of magnitude. Some seeps dry completely during the summer. Sustained flows from springs are low; only 4 springs on the Skyline permit area were flowing at 10 gpm or more during the 1978 autumn inventory, and most flowed at 2 gpm or less. Flows are also sensitive to the amount of precipitation during the winter. OSM contract staff surveyed springs on the Skyline property in 1983 following a very wet winter. One unidentified spring was flowing at 300 gpm in late June, but by early August it was flowing only 4 gpm. A nearby spring flowed 100 gpm in June and could not be located, apparently because it was dry, in August (Engineering Science, 1984, p. 34). An additional Seep and Spring survey was conducted by the Skyline Mine in the Winter Quarters / North Lease area in 1992 and 1993, which was used in determining the current water monitoring locations. Graphs of selected groundwater wells, springs and streams comparing historic flow to the Palmer Hydrologic Drought Index (PHDI) are provided in Appendix A of the July 2002 Addendum to the PHC in the Skyline MRP, and were last updated with data from the 1<sup>st</sup> quarter of 2003. These graphs illustrate how the springs in the Blackhawk Formation respond rapidly to seasonal and to climatic cycles. This indicates that the springs are fed by discharge from a groundwater system that is in good communication with the surface and annual recharge events. Through the 3<sup>rd</sup> quarter of 2005, no obvious changes in flow in the springs, seeps, or elevations in the groundwater wells located in the Blackhawk Formation have been noted; despite the significant mine inflows encountered in the Skyline Mine since 2001. This determination is based on the groundwater monitoring sites outlined in the Skyline MRP, for which data is available in the Division's Coal Water Quality Database.

According to the Seep and Spring survey conducted in the White Oak area in the summer of 1990, a total of three seeps/springs are affected by the 2001 Surface mining in the area. Seeps/springs S25-13, S25-14, and 30-1 are all located up gradient of the surface mining. Seep/Spring S25-13 is the only site that provided consistent enough flow to be continually monitored. Recorded quarterly flow measurements from site S25-13 ranged from 0 to 60 gpm, and averaged <5 gpm. Any flow from the three seeps or springs still reported to Whisky Creek and were not impacted by the surface mining.

The Blackhawk-Star Point aquifer provides baseflow to Mud Creek and the lower reaches of Eccles Creek, but the volume of ground water discharged from the regional Blackhawk-Star Point aquifer has not been quantified. Vaughn Hansen Associates (1979) estimated that 64% of the flow of Eccles Creek was from ground water discharge, with the major portion of this flow entering the stream from the Star Point Sandstone. The Star Point can be presumed to provide

baseflow to lower reaches of other Mud Creek tributaries where it is exposed. Low flows of Mud Creek are sustained principally by ground water flowing up from the regional Blackhawk-Star Point aquifer (Waddell, 1983b). Discharge through fractures such as the O'Connor fault and the Pleasant Valley fault zone has been documented. Some baseflow also probably occurs directly through un-fractured but permeable zones in the Star Point Sandstone. The Star Point Sandstone does not crop out in the headwater drainages of Mud and Huntington Creeks and the regional Blackhawk-Star Point aquifer does not discharge from springs, or otherwise contribute to surface flow in these areas.

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**WATER QUALITY**

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## **V. IDENTIFICATION OF HYDROLOGIC CONCERNS**

(IDENTIFY HYDROLOGIC RESOURCES THAT ARE LIKELY TO BE AFFECTED AND DETERMINE WHICH PARAMETERS ARE OF IMPORTANCE FOR PREDICTING FUTURE IMPACTS TO THOSE HYDROLOGIC SYSTEMS.)

The Class 3A streams in the CHIA are protected for cold-water species of game fish and other cold-water aquatic life, including the necessary aquatic organisms in their food chain. The drainages of upper Huntington Creek and Mud Creek have both been identified as habitat for naturally reproducing populations of cutthroat trout. Scofield Reservoir is stocked with rainbow trout, but contains cutthroat trout that have reproduced in tributary streams, including Mud, Eccles, Winter Quarters, and possibly Boardinghouse Creeks.

Burnout Creek has been identified as a spawning habitat for the native Yellowstone cutthroat trout population in Electric Lake. Cutthroat trout have been observed in large numbers in James Creek, just south of Burnout Creek, during spawning season. Boulder Creek has been studied as a stream that could be developed for spawning, and Skyline has provided funds to the USDA Forest Service for construction of a fish ladder to bypass Boulder Reservoir. Utah Division of Wildlife Resources is concerned about the potential loss or alteration of these and other important fish habitats in and around Electric Lake as a result of coal mining activities.

There are 194 surface water rights in the CIA; 106 for stock watering, 25 for irrigation, 55 undeclared, and the remaining 8 for other uses. Most streams in the CIA have water rights filed on them. Water rights have been filed on 112 springs and 23 wells or tunnels. Stock watering was the declared use on 62 of the water rights, 41 were for other uses, and the remaining 32 were undeclared. Springs and seeps are important to wildlife, though there are no filed rights that declare this as a use. Specific water rights information for the North Lease was updated in October 2002 (second binder volume 4- Water Rights).

Electric Lake is a reservoir owned and operated by PacifiCorp. PacifiCorp also owns roughly one-third of the water shares in the reservoir, and uses approximately 12,000 acre-ft annually, to cool their coal-fired electric generating plant in Huntington Canyon. The Utah Division of Wildlife Resources typically requires minimum flows of 12 cfs in winter and 15 cfs in summer below the lake to maintain a quality aquatic habitat. In 2002, the minimum flow requirement was reduced to 6 cfs because of low storage levels in Electric Lake. PacifiCorp also purchased the majority of remaining water shares in the irrigation company to maintain plant operations. For those reasons, the agricultural needs of the Huntington Cleveland area were at a minimum, or were not met during the 2003 growing season, since little water was delivered downstream of the Huntington Power Plant. Hydrologic impacts to Electric Lake affect everything from wildlife, to agriculture, to power generation along the Wasatch Front. Whether the possible connection of water entering the Skyline Mine is impacting Electric Lake continues to be studied by all parties.

Both the Skyline and White Oak Mines utilize water from wells in Eccles Canyon that were drilled into fault zones in the Star Point Sandstone. Wells near the Skyline and White Oak Loadouts in Pleasant Valley produce water from both alluvium and the Star Point Sandstone. Water from these wells is for domestic, stock watering, and other uses.

During the 1979-1980 water year, Mud Creek contributed approximately 16% of the inflow to the Scofield Reservoir. Scofield Reservoir discharges into the Price River, which is used for irrigation in Castle Valley and provides the municipal water supply for the city of Price. The Upper Huntington Creek drainage contributes an unknown amount to the total discharge of Huntington Creek, but estimates indicate it could be 25% or more.

Table 13 lists potential impacts to the hydrologic resources, indicates where there is a possibility for cumulative impact outside the permit areas, and identifies analytical parameters or other indicators that need to be monitored to track potential impacts of the permitted mines.

Seasonal periods of high suspended-solid loads in the streams, and periods of high runoff are typical. Therefore, fine sediments alternately settle in, and later are flushed from, the streambed. The high flows leave clean gravel beds for trout spawning. Sediment cleared from the streambed simply moves downstream, eventually accumulating in Electric Lake or Scofield Reservoir. When runoff is low, fine sediments may remain, and spawning gravels become unavailable. Fine sediments increase trout egg and fry mortality through suffocation. Invertebrates are also impacted by sedimentation through loss of habitat or mortality. Invertebrate diversity may decrease, since resistant or adaptive species will remain. Impacts on invertebrates may reduce the supply of food for the trout. Construction, mining, and other activities produce the same negative impacts that nature does by decreasing flow, or increasing sedimentation beyond the capacity of the stream to flush itself.

Fine sediments, including coal fines, have covered portions of the streambed below the Skyline Mine and have been trapped behind beaver dams in Eccles Creek. Some beaver dams have been removed in an attempt to increase access from Scofield Reservoir to Eccles Creek for spawning cutthroat trout, and to facilitate the flushing of fine sediments from the streambed. Sediment traps along Mud Creek have been suggested by UDWR as a solution that would maintain access to the stream for spawning trout while reducing sedimentation in Scofield Reservoir. The increased flow in Eccles and Mud Creeks, resulting from the pumping from the Skyline Mine, has had a beneficial impact by flushing more fine sediment from these streams.

Temperature increases can reduce dissolved oxygen in a stream. Changes in temperature may also directly influence algae growth rates. Winget (1980) found that water temperatures in upper Huntington and Eccles Creeks equilibrated quickly with air temperatures because of the turbulence from rough channels and low flows. However, the Division found that the temperature of Eccles Creek increased, from 43° F to 54° F, as it passed through the 72-inch bypass culvert and joined with the sediment pond discharge (The Division, 1988). However, since the streams within the CIA have steep gradients and rocky beds, the entrainment of air and



transfer of oxygen, and equilibration with air temperature should be sufficient to eliminate temperature as a factor in habitat quality.

Toxic materials in the water will reduce trout and invertebrate populations through mortality or avoidance. Nitrite concentrations in excess of 0.06 mg/L result in trout mortality. The long term LC<sub>50</sub> exposure level for trout to nitrate is 1060 mg/L. Phosphorus in excess of 0.04 mg/L is not toxic to trout, but does lead to eutrophication of the stream. The UDWR identified toxic levels of nitrite, and eutrophication from excessive nitrogen and phosphorus as causes of fish and invertebrate declines in Eccles Creek in 1987 - 1988.

Increased TDS has not been identified as a problem in any of the fisheries. There is no water quality standard for TDS for aquatic wildlife, but 1200 mg/L is the limit for agricultural use. There is a possibility of cumulative effect outside of individual permit boundaries in the Mud Creek drainage, but none has been noted. TDS and sulfate exceeded UPDES limits at the Skyline Mine in the past, because of gypsum contamination in the limestone used for dust control. The discharge returned within UPDES limits after application of contaminated rock dust ceased, and continuing flow diluted or flushed residual contamination.

Sediment, total nitrate, phosphorous, and dissolved oxygen have been identified as water quality concerns for Scofield Reservoir. High nitrogen and phosphorus levels lead to increases in algae and aquatic vegetation (eutrophication), which in turn leads to a deterioration of water quality. The reservoir may become eutrophic, unless measures are taken to limit nutrient inflow (Waddell and others, 1983a). The increased flow in Eccles and Mud Creeks, resulting from the pumping from the Skyline Mine, may have had a beneficial impact by increasing the inflow of low TDS water into the reservoir; however, the volume of all nutrients being added by this flow has not been determined yet. The increased flows have not appreciably increased the amount of total phosphorous in Mud Creek (measured at MC-3; see Figure 12, Appendix A).

During the 1979-1980 water year, Mud Creek contributed approximately 16% of the inflow to the reservoir, 18% of the total dissolved solids (TDS), 28% of the total suspended solids (TSS), 18% of the total nitrogen, and 24% of the total phosphorous. During snowmelt, concentrations of nitrogen and phosphorus reached 21 and 4.3 mg/L at the Eccles Canyon gauging station. Most of this was in suspended form, and these unusually high concentrations were probably due to flushing of residual debris from 27 acres of forested land cleared in 1979 for fire protection around the mine portal and road right-of-ways. (Waddell and others, 1983a)

Perched systems have limited storage and recharge capacities, and when they are intercepted by mining operations the resulting in-mine flows decline rapidly. Draining of these perched systems may cause individual springs or seeps to disappear, but should have little impact on the hydrologic balance of the area. Flows into the mines that persist for more than 30 days are typically considered as *possibly* intercepting surface water through a natural, or subsidence induced fracture system. In the case of the Skyline Mine, the majority of inflow water is encountered in the floor and along fracture zones, and has been characterized by Canyon Fuel as likely coming from a deeper regional aquifer, but including a component of surface recharge.

Studies carried out by Canyon Fuel Company and PacifiCorp have not confirmed the source of this inflow water. The studies are discussed in more detail elsewhere in this CHIA.

Surface-mining methods employed at the White Oak mine temporarily disrupted the shallow groundwater and diverted surface flows in the area. Seeps and surface flows that formerly reported to Whisky Creek have been re-established in the reclamation of the mine site. The Division (AMR section) constructed several French drains to ensure that the flow from significant seeps reports to the surface, and eventually to the Whisky Creek drainage.

Operations at the Skyline Mine have drawn down the potentiometric surface of the Star Point regional aquifer, and to a much lesser degree in the Blackhawk. This drawdown can induce increased recharge and downward flow through the overlying unsaturated zone through fracture zones. This would have a minimal, probably undetectable effect on perched aquifers or soil moisture because of the generally low hydraulic conductivity of the Blackhawk Formation. Since Canyon Fuel finished mining in the southwestern portion of the mine, the Star Point potentiometric surface has started to recover.

Water users have expressed concerns that water intercepted underground may be discharged into a watershed other than the one where the ground water was originally destined. According to the Utah Coal Mining and Reclamation Act and rules, a mine may divert water underground and discharge to the surface, if material damage to the hydrologic balance outside of a permit area is prevented; and disturbance to the hydrologic balance within the permit area is minimized (R645-301-731.214.1). Furthermore, any state-appropriated water affected by contamination, diminution, or interruption resulting from underground mining must be replaced (R645-301-731.530). The Division evaluates a mine's Probable Hydrologic Consequences Determination (PHC) and updates the CHIA prior to permitting, and reviews water monitoring data during mining and post-mining reclamation to determine if adverse hydrologic impacts, *as defined by the rules*, can be demonstrated. Underground mining may result in some diversions of intercepted ground water into drainages that are not topographically within (above) the area where the water was encountered. The PHCs of the mines in the Mud Creek / Upper Huntington Creek CIA have demonstrated that the large quantities of water intercepted underground are *mostly* ancient. Therefore, the inflow water is hydrologically isolated from surface expression of springs, seeps, and streams. Water monitoring activities in the area show no change to water quantity in streams, springs, or wells located in the Blackhawk Formation; except those quantity changes that can be directly attributed to the drought. If it is subsequently demonstrated that the mining has caused, or will cause a diminution, contamination, or interruption of an *appropriated* water right, or a material impact to the hydrologic balance (either within or outside of the permit area), the Permittee will be required by the Division to minimize the impact and replace any appropriated water right.

## HYDROLOGIC CONCERNS Mud Creek &amp; Upper Huntington

Parameters of Importance and Other Indicators for Predicting Future Impacts	<sup>M</sup> Sediments <sup>M</sup> Fish and Macroinvertebrates	<sup>M</sup> Flow <sup>M</sup> Sediments <sup>M</sup> Fish and Macroinvertebrates	<sup>M</sup> Sediments <sup>M</sup> TDS <sup>M</sup> pH <sup>M</sup> Nutrients <sup>M</sup> Specific cations and anions <sup>M</sup> Oil and Grease <sup>M</sup> Fish and Macroinvertebrates	<sup>M</sup> Flow <sup>M</sup> Sediments <sup>M</sup> Fish and Macroinvertebrates	<sup>M</sup> Flow <sup>M</sup> Sediments <sup>M</sup> Fish and Macroinvertebrates <sup>M</sup> TDS <sup>M</sup> pH <sup>M</sup> Nutrients <sup>M</sup> Specific cations and anions	<sup>M</sup> Flow Age dating Tracer dye Geophysics Groundwater monitoring Age dating	<sup>M</sup> Flow
Possible Cumulative Effect Outside Permit Areas	YES	YES	YES	YES	YES	YES	YES
POTENTIAL HYDROLOGIC IMPACTS	<sup>M</sup> Increased sediment yield from disturbed areas - Alteration or loss of fisheries in streams and reservoirs. Increased rate of sedimentation in reservoirs. Coal spillage from hauling operations and storage. Loss of riparian habitat.	<sup>M</sup> Flooding or streamflow alteration - increase or decrease in streamflow.	<sup>M</sup> Contamination of ground and surface water from acid- or toxic-forming or toxic materials - Contamination of surface water from coal hauling operations and storage. Hydrocarbon contamination from above-ground storage tanks or from the use of hydrocarbons in the permit area. Contamination from road salting. Gypsum used in dust control contaminating mine discharge. Nutrients in mine discharge.	<sup>M</sup> Subsidence damage to springs and streams - increased sediment load, diminution of flow, physical barrier to fish migration.	<sup>M</sup> Alteration or destruction of fisheries and aquatic habitats - loss of flow, loss of access to stream, loss of fish spawning habitat, increased sediment load, acute or chronic toxicity, eutrophication, loss of food supply.	<sup>M</sup> Loss of ground water or surface water availability - water rights, wildlife uses.	<sup>M</sup> Reduction of flow due to inter-basin transport of intercepted water.

Table 13

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Mud Creek & Upper Huntington **HYDROLOGIC CONCERNS**

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## **VI. MATERIAL DAMAGE CRITERIA - RELEVANT STANDARDS AGAINST WHICH PREDICTED IMPACTS CAN BE COMPARED**

Water within the CIA is used for watering livestock and wildlife, mining coal, domestic use, fisheries, and recreation. Downstream, the water is additionally used for irrigation and domestic and industrial needs. Land within the CIA is used for wildlife habitat, grazing, recreation, and mining coal. Anticipated post-mining uses are for wildlife habitat, grazing, and recreation.

### **Quality**

Water quality standards for the State of Utah are found in R317-2, Utah Administrative Code. The standards are intended to protect the waters against controllable pollution. Waters, and the applicable standards, are grouped into classes based on beneficial use designations.

The Utah Division of Water Quality has classified (latest classification December 7, 2001) Scofield Reservoir as:

- 1C - protected for domestic purposes with prior treatment by treatment processes as required by the Utah Division of Drinking Water.
- 2B - protected for secondary contact recreation such as boating, wading, or similar uses
- 3A - protected for cold-water species of game fish and other cold-water aquatic life, including the necessary aquatic organisms in their food chain.
- 4 - protected for agricultural uses including irrigation of crops and stock watering.

### **Scofield Reservoir:**

- Is a culinary water source.
- Is one of the top four trout fishing lakes in Utah.
- Has over a one million dollar annual recreational fishing value.

(E-mail from Louis Berg, Utah Division of Wildlife Resources, to Division dated February 4, 2002).

The Utah Division of Water Quality has classified (latest classification December 7, 2001) Electric Lake as:

- 2B - protected for secondary contact recreation such as boating, wading, or similar uses
- 3A - protected for cold-water species of game fish and other cold-water aquatic life, including the necessary aquatic organisms in their food chain.
- 4 - protected for agricultural uses including irrigation of crops and stock watering.

Electric Lake:

- Provides cooling water for the Huntington Power Plant, and
- Is a major source of agricultural water for the Huntington Cleveland Irrigation Company.

Streams in both basins are classified as:

1C, 3A, and 4.

In addition, surface waters located within the outer boundaries of a USDA National Forest, with specific exceptions, are designated by the Utah Division of Water Quality as High Quality Waters - Category 1 and are subject to the state's antidegradation policy. This antidegradation policy states that waters shall be maintained at existing high quality, and new point source discharges of wastewater (treated or otherwise) are prohibited (Utah Administrative Code, R317-2-3.2 and R317-2-12.1). All of the upper Huntington Creek drainage, and most of the headwater drainages of east flowing tributaries to Mud Creek, (including the Skyline Mine disturbed area) are within USDA Forest Service boundaries and are therefore protected by this policy. The White Oak Mine, both loadouts, and the waste rock disposal site are outside forest boundaries.

The Utah Water Quality Board agreed in their September 24, 2001 meeting to reclassify Electric Lake as High Quality Waters – Category 2. Category 2 is defined as “...designated surface water segments which are treated as High Quality Waters – Category 1; except that a point source discharge may be permitted, provided that the discharge does not degrade existing water quality.” Both the effluent and the lake were to be sampled for a period of two years for a full suite of metals and nutrients to ensure that the mine water is not of a lower quality of water than exists in Electric Lake. Unfortunately, due to equipment failure and high TDS, the JC-3 well (which discharged directly from the mine into Electric Lake) is no longer pumping. Canyon Fuel and PacifiCorp have continued to sample the water quality of Electric Lake and the JC-1 well.

The Utah Department of Environmental Quality, Division of Water Quality can authorize a coal mine to discharge into surface waters under the Utah Pollutant Discharge Elimination System (UPDES). The permits for the mines contain site-specific limitations on total dissolved

solids, total suspended solids (or total settleable solids for precipitation events), iron, oil and grease, and pH. The Skyline Mine UPDES permit has an additional limitation on sulfate for discharges into Eccles Creek, and a whole suite of metals and nutrients for discharges into Electric Lake.

The water quality standard for nitrate in Class 1C waters is 10 mg/L. Nitrate levels above 4 mg/L are considered an indicator of pollution, usually from sewage, in all waters. For trout, the long term LC<sub>50</sub> exposure level to nitrate is 1,060 mg/L.

There is no water quality standard for nitrite, but concentrations in excess of 0.06 mg/L produce mortality in cutthroat trout (UDWR, 1988).

The water quality standard for Class 3A waters for phosphorus is 0.05 mg/L. Levels in excess of 0.04 mg/L are not toxic to trout, but are excessive and promote eutrophication (UDWR, 1988). By state standards for Class 1C, 2A, 3A, and 3B waters, phosphate in excess of 0.05 mg/L is a pollution indicator.

The recommended limit for MBAS, a detergent or surfactant, is 0.2 mg/L (Steve McNeil, Utah Dept. of Health, personal communication in the Division, 1988).

There is no water quality standard for oil and grease, but the UPDES permit limit for both the White Oak and Skyline Mines is 10 mg/L. A 10 mg/L oil and grease limit does not protect fish and benthic organisms from soluble oils such as those used in longwall hydraulic systems, and UDWR has recommended soluble oils be limited to 1 mg/L (Darrell H. Nish, Acting Director UDWR, letter dated April 17, 1989 to Dianne R. Nielsen, Director the Division of Oil, Gas, and Mining).

Increased TDS has not been identified as a problem in any of the fisheries. There is no water quality standard for TDS for aquatic wildlife, but 1,200 mg/L is the established limit for Class 4, agricultural use.

Physical or chemical indicators alone do not fully evaluate water quality in streams. Macroinvertebrates are excellent indicators of stream quality and can be used to evaluate suitability of a stream to support a trout fishery and other aquatic life. Baseline studies of invertebrates by the USGS (Waddell, 1982) and Winget (1980) and studies done in conjunction with mine operations (Coastal States, 1993; ERI, 1992) provide standards against which actual stream conditions can be evaluated. Cutthroat trout populations are also excellent indicators of stream quality. UDWR surveys of trout populations in Eccles, Winter Quarters, and Huntington Creeks have established baseline conditions.

The maximum temperature for Class 3A waters is 20° C (68° F). The maximum allowable change for Class 3A waters is 2° C (3.6° F).

### **Sedimentation**

Sedimentation of reservoirs and the eventual loss or diminution of their value is inevitable. Waddell and others (1983a and b) examined sedimentation in Scofield Reservoir. A bathymetric survey was done to:

- a) Estimate total sediment yield from inflowing streams; and
- b) Provide detailed bathymetric measurements at selected cross sections to allow more accurate evaluation of future deposition.

The rate of sediment accumulation and deposition was estimated by using <sup>210</sup>Pb to determine the relative ages of sediment samples from cores. Increased sedimentation in the reservoirs due to mining in the adjacent drainages might be detectable using such techniques, but direct monitoring of inflowing streams is probably more effective.

Changes in sediment size distribution in streams can be determined by comparison with past studies (Winget, 1980; Coastal States, 1993, Table 2.8-3). Winget identified 15% or more of materials finer than 0.85 mm in diameter as a critical measure of biotic potential, in other words whether or not fish eggs and fry and many macroinvertebrates would be suffocated.

### **Quantity**

There are no prescribed standards to assess impacts to water quantity as there are for water quality. It has been determined that the flow regime in the Mud Creek – Upper Huntington Creek impact area may be complicated with preferential fracture-flow and flow along faults. A component also related to quantity is the mixing of water from more than one source. To help assess and evaluate any impacts to the flow regime, the waters need to be characterized with as many unique identifiers as possible. As outlined earlier in this report, they include, but are not limited to the following: significant reduction in historic flows that cannot be attributed to drought conditions; age-dating, solute water analysis, field parameters, tracer-dye, geophysics, hydrologic modeling, and routine surface- and ground-water monitoring all contribute to identifying the origin of waters. The Division will use measurements of flow (both receiving and source waters), characterizing the water, and impacts to the receiving and source waters in assessing impacts to quantity.

Based on correlations of low flows in several streams in the southern Wasatch Plateau, Waddell (Waddell et al., 1983b) found that with 5 years of continuous discharge records, monthly flows for August, September, and October could be estimated with a standard deviation of 20%. From measurements taken in 1979 and 1980, it was calculated that the average ratio of the low flows of Mud and Fish Creeks was 0.42 (calculated for October, the low-flow month with the least variation).



Waddell (Waddell et al., 1983b, p. 129) approximated the amount of water that would need to be diverted from, or to the Mud Creek basin, before it could be detected. Assuming the following:

- 1) A 20% standard error,
- 2) An average flow ratio of 0.42 between Mud Creek and Fish Creek, and
- 3) An average flow of Fish Creek in October of 330 acre-ft/year (5.4 cfs).

He calculated the amount as follows:

$$(\pm 0.20)(330 \text{ acrefeet})(0.42) = \pm 28 \text{ acrefeet} = \pm 0.45 \text{ cfs.}$$

A long-term increase or decrease of flow in Mud Creek of at least 0.45 cfs would be detected 68% of the time, by correlating the October flows of Mud and Fish Creeks. The USGS had a stream-gauging station on Eccles Creek during 1979 and 1980. They have had stream gauging stations on Mud, and Fish Creeks since 1978 and 1931, respectively; and as of January 2006, continued to monitor them on a regular basis.

Eccles Creek and Mud Creek have obviously received excessive amounts of mine discharge water since 2001. Most of this water appears to originate from the Star Point Sandstone. This is at least partially supported by the fact that streams and springs in the Upper Huntington, Upper Eccles, and Upper Mud Creek drainages do not appear to be depleted as a result of the increased mine discharge.

Unfortunately, long-term flow data for Burnout, Boulger, and Huntington Creeks draining into Electric Lake are not available. In June 2002, PacifiCorp began monitoring cumulative inflow. This was at a time when the lake was at a historic low. The monitoring continued through mid-April 2003, using a flume located in the lake bottom immediately opposite James Canyon. This flume also measures mine water discharge input from the James Canyon wells to the lake. Based on measured data, PacifiCorp estimates the flows of unmeasured side tributaries below James Canyon to be approximately 14% of the Huntington Creek flow during times when it is not possible to measure them. The flume opposite James Canyon was installed in June 2002 and became non-functional in April 2003 due to the spring runoff, which was still far from “normal” levels, but higher than in the previous “extreme” drought year. The flume was recalibrated in June of 2003 and continues to collect flow data when not inundated. Because the lake level was rising, PacifiCorp installed a second flume further upstream, but still below Boulger Creek. Estimated discharge from the upper Huntington Creek basin is 16,000 acre feet per year (22 cfs) based on the measured discharges from Burnout and Huntington Creeks. This estimated number is supported by comparing the continuous flow recorded at the mouth of Eccles Creek (Table 3) and using the same flow volume per acre of land for the Upper Huntington basin.

The flow data being collected in the upper Huntington drainage will document the flow information necessary to make a quantifiable determination of whether any quantity of water is

being lost from the basin. Other crucial information will be the data supplied by PacifiCorp in regards to Electric Lake such as discharge records from the dam, long-term precipitation data, long-term evaporation data, and long-term stage-volume records for the lake.

## VII. ESTIMATE OF THE PROBABLE FUTURE IMPACTS OF MINING ON THE HYDROLOGIC RESOURCES

### Quality

Mine discharges of water to both Eccles Creek and Electric Lake are being closely monitored to ensure that the mixing of mine water does not create any degradation of the existing hydrologic regime. Water quality standards are outlined in Section VI. Any future estimates of impacts will be based on the outlined criteria. Currently (Jan. 2006), no adverse impacts are being observed, but any possible adverse trends are being documented.

### Quantity

#### Increased Streamflow

Average discharge from the White Oak #1 Mine between 1981 and 1989 was 0.19 cfs (Table 724.100a). No water had been discharged from the White Oak #2 Mine as of 1993. Discharge from Pond 004 was sporadic from 1995 through 2000 with no discharges after August 1999. Average discharge flow from 1995 through 1999 was 74 gpm/day. Coal production from both mines has averaged approximately 0.5 million tons per year, so a very rough estimate of water production is 0.4 cfs per million tons of coal mined. Records indicate that only sporadic flows were encountered. Water is no longer being discharged from the White Oak Mine.

Skyline's records show that Mine #3 first discharged water in 1983, and Mine #1 first discharged water in 1989. Through the end of 2000, the average discharge from Mine #1 was 0.47 cfs, and 0.58 cfs from Mine #3. This water was always discharged into Eccles Creek through the sediment pond. When streamflow was naturally low in the late summer to early autumn, the discharge from the Skyline Mine was estimated to account for as much as 60% to 70% of the baseflow in Eccles Creek.

In October of 2003, pumping of mine inflow waters from Skyline Mine into Eccles Creek increased the streamflow from normal amounts of approximately 300 gpm, to as high as 10,500 gpm. From August 2001 to December 2005, the average discharge to Eccles Creek has been 5,601 gpm. Eccles Creek is well armored and has shown little or no visual indication of erosional impacts. These increased mine-water discharge flows have increased the average flow in Mud Creek to about 1.2 times normal (pre-1999) amounts. Mud Creek has always shown some minor visual indication of stream bank erosion, and very little has changed with the increased flows. Both streams are being continuously monitored to determine possible impacts. Studies carried out on Eccles and Mud Creeks so far show that there have been no significant morphological changes to the creeks (EarthFax 2002, 2003, 2004). Discharge into Eccles and Mud Creeks dropped to approximately 3,500 gpm with the addition of the JC-3 Well. Since JC-

3 was shut down, the flow has averaged just 3,856 gpm. This is mostly because the southwest portion of the mine was allowed to fill, and steady-state inflows are much decreased. Based on the current information and conditions, the observed and estimated impacts due to increased streamflow from mine-water discharges are minimal.

#### Mine In-flows

Prior to January 2000, mine discharge from the Skyline Mine was typically below 500 gpm. Additional waters (any flows above the 500 gpm) encountered in the mine were used in the operation of the mine. Figure 10 (Appendix A) illustrates the amount of water discharged from the mine and how it has increased with time. As outlined earlier, these inflows appear to be originating predominantly from faults and the fractured Star Point Sandstone located below the mine. Figure 11 (Appendix A) illustrates the cumulative discharge of water from the mine since 1999. As outlined in Table 1, mine-inflows most recently totaling on the order of 3,100 gpm are of concern to the Division because of the potential impact to the surface- and ground-water being used in the Mud Creek and Huntington drainages. The Division is concerned that these increased flows may have an adverse impact on the receiving streams/reservoirs and any waters that are being used within the basin. The Division must ensure that existing waters and water rights are not being diminished. Other than making a determination on impacts to the receiving streams/reservoirs, and surface- and ground-water being used in the basin, the Division does not regulate the use or distribution of mine-discharged waters. Current information indicates the water being discharged is not adversely impacting the receiving streams/reservoirs, or diminishing flows within the respective basins.

For the foreseeable future, Well JC-1 is anticipated to discharge approximately 4,000 gpm of groundwater to Electric Lake, providing about 530 acre-ft of water per month to Electric Lake. Photos 1 through 3 (Appendix B) illustrate the armoring provided by PacifiCorp to minimize any impacts to the lake bottom at the point of discharge. The ability to provide high quality water at a significant rate to the lake is considered a positive impact on the hydrologic resource of Electric Lake.

Underground mining may result in some diversion of intercepted ground water into drainages that are not topographically within (above) the area where the water was encountered. If it is *demonstrated* that mining has caused or will cause a diminution, contamination, or interruption of an *appropriated* water right, or a material impact either within or outside of the permit area, the Permittee will be required by the Division to address means of minimizing the impact and replacing any appropriated water rights. Evaluations of PHCs and the preparation of this CHIA do not indicate that there is any convincing direct evidence that such impacts have or will result from the mining in the Mud Creek / Upper Huntington Creek CIA. As a consequence, there is no reason to require operators to propose alternatives for disposing of the displaced water or other possible actions as part of the MRP at this time. The MRP does contain a water replacement plan for those State-Appropriated Water Rights that may be impacted by mining.

With no apparent adverse impacts to the receiving stream, the increased discharge of mine in-flows to the Mud Creek and Huntington Creek drainages are considered to have a positive impact, providing additional water to the Scofield and Electric Lake reservoirs.

*Studies Related to Mine Inflows*

**I.** PacifiCorp has conducted several geophysical studies in an attempt to establish a flow path along the known faults trending from Electric Lake to the Skyline Mine. These studies have proven to be inconclusive. A Resistivity/IP survey indicated that the faults contained water, however it also indicated saturation *above* the elevation of the lake. In addition, it suggested that portions of the saturated zones contain saline water. There are several reasons why this study does not help to conclusively prove a connection between the lake and the mine:

- The depth of the survey was at least 350-feet above the elevation of the Mine,
- The studies were conducted approximately one year after the Mine began encountering significant water from the faults. If the portion of the fault associated with both the lake and mine had a direct connection, the faults would be devoid of water above the elevation of the Lake by that time,
- The only significant fault-related inflow that Skyline Mine has encountered has come from the floor of the mine. Any inflows encountered from the roof have been of limited duration, consistent with Blackhawk formation function, and
- No saline water has been encountered within the Mine.

**II.** PacifiCorp also conducted an induced-electrical geophysical survey (AquaTrack – Sunrise Engineering, Inc.), which showed a potential flow path from Electric Lake to the Skyline Mine. However, the preferential flow path did not follow known fault lines, and the survey does not indicate a flow direction, or whether there is flow at all. The presence of water with little flow is consistent with known Blackhawk geology. Also, the faults that were the focus of the study also trend through Electric Lake to the south – no study was conducted on the other side of the Lake to see if conditions were consistent throughout the faults. A study less-biased toward one preconceived solution would be more in line with the Scientific Method. In any case, the Division, as an unbiased arbiter, must take into account the big picture, and investigate all reasonable possibilities for Electric Lake's water loss and the Skyline Mine inflows. The Division has scrutinized all of the information available, from all possible resources in an attempt to fully understand the situation. Unfortunately, none of the studies done to date can *conclusively* show what is happening.

**III.** Canyon Fuel Company commissioned a numeric groundwater model of the Skyline area in an effort to define the outer limit of where the water is being drawn (HCI 2002, 2003, 2004). This model concluded that:

- The majority of the inflow water comes from the Star Point Sandstone,
- The water flows through the fractured fault system in faults with less than 50 ft. displacement,
- The groundwater gradient in the Star Point Sandstone is from south to north, and
- The system is confined by faults with large displacements (>100 ft.)

The Division has several reservations about this model, and is skeptical about the reliability of the results. Among the reasons the Division cannot solely rely on the results of this model are:

- The model is based on just 20 wells to model a 140 mi<sup>2</sup> area,
- Half of the data was acquired after the inflows began,
- Many assumptions had to be made to complete the model, including critical parameters, and,
- The model was generated using proprietary software, therefore the Division was unable to attempt to repeat the experiment and do sensitivity testing.

**IV.** Canyon Fuel also studied the chemical composition of the inflow water vs. that of the lake (Skyline PHC, Appendix G). The findings indicated that:

- The chloride content of Electric Lake waters is nearly four times that of mine inflow waters. Chloride is considered a conservative species, meaning that it is not attenuated from a groundwater system, other than by dilution (Fetter, 1988)
- Mine inflow waters contain about 50% greater bicarbonate concentrations than lake waters, and over 3 times the magnesium content of lake waters. Since the Electric Lake waters are supersaturated with respect to calcite and dolomite, they cannot dissolve carbonates to “pick-up” bicarbonate or magnesium without an external source of CO<sub>2</sub>. The  $\delta^{13}\text{C}$  composition of the groundwater shows that it has not been influenced by external sources of CO<sub>2</sub>.
- The temperature of the major mine inflows (issuing from the floor) ranges from 56-60 °F; mine inflows from the roof (Blackhawk) have a temperature range of 48-50 °F.
- The dissolved oxygen in the inflows is 10 times less than that of the lake water. It is possible to lose the dissolved oxygen, but more unlikely if there is a direct connection.

**V.** To better characterize the origin/residence of waters, significant study of the age of water has been conducted by both PacifiCorp and Canyon Fuel Company.

**Va.** Canyon Fuel Company continues to collect information on tritium and other age-dating parameters. Using tritium analysis, which functions as an indicator of modern water (in contact with the atmosphere post 1950's), Figure 9 (Appendix A) outlines the relative ages of waters sampled in-mine. The presence of tritium suggests that there is some percentage of modern water present in the water being discharged from Well JC-1. Tritium unit values (TU) for samples collected in Electric Lake to date range from 7.00 to 12.6 TU, and average 8.02 TU for samples collected in 2002 and 2003. The tritium levels in Electric Lake continue to be monitored, however with the significantly lower-tritium water of JC-1 continually being added to the Lake (4.01 TU below the James Canyon flume), the lake numbers appear to be getting lower. Tritium values for springs located within the permit area (Blackhawk Formation) range from 10.6 to 21.6 TU and average 16.1 TU. The only mine inflow where trace amounts of tritium were measured is the 10L inflow.

Other age-dating methods used include radiocarbon and environmental tracers (CFC's, He, Ne, N<sub>2</sub>, Ar). <sup>14</sup>C dating shows the 10-Left inflow waters to be 4,600 years old and JC-1 well waters (in the same fault as 10-Left) to be 6,300 years old. Helium isotope ratios suggest a percentage of the water located in the 10-Left area of the Skyline Mine is about 5 years old  $\pm$  3 years. The studies and analyses (Petersen, 2002; Appendix G of October 2002 Addendum to the PHC) suggest a component of the water being discharged from the Skyline Mine is of modern origin (20 to 35%). The report (Petersen 2002) goes on to say that with existing data Canyon Fuel cannot determine the source of the modern component of the water. They do not say if further studies could reveal the source. They posit that: *"...the modern water is likely derived from either 1) leakage from shallow or intermediate depth, active groundwater systems that surround the coal seams in the vicinity of the fault inflow, 2) losses from nearby surface water systems that contain abundant tritium, or 3) a combination of both of these sources ... Although the precise origin of the small modern water component has not been determined, it is clearly evident that Electric Lake water cannot be a primary source of the fault-inflows."* (Petersen 2002)

**Vb.** PacifiCorp completed their own draft analysis of the tritium and environmental tracers in July of 2005. The study concluded that:

- "The tritium, dissolved gas, and dye tracer results are consistent with a model of *rapid* fluid flow along fractures with mass exchange via diffusion with the surrounding porous matrix",
- "The systematic increase in tritium in JC 1 and other underground monitoring points is strong evidence for a fracture controlled flow system that is conveying water (5,000 gpm from lake) from surface sources towards underground workings and dewatering wells",
- "Water discharging from well JC 1 is currently a mixture of approximately 22 to 45 % modern water that is derived from surface sources,"
- "The tritium content of JC 1 will continue to increase, but will approach a value that is less than the modern value of surface water ... more than 10 years are required before the tritium value will stabilize", and
- Just 365 fractures with an aperture of 0.25 mm would be needed to carry the 5,000 gpm from the lake to the underground workings.

Some of the Division's concerns with this report include:

- The "cubic law" seems to have been applied incorrectly (used vertical gradient instead of gradient along fracture length— instead of the 350 (0.25 mm aperture) fractures the report says are needed to move the 5,000 gpm between the lake and the mine, the calculation along the fracture shows that 3,727 fractures of that size would be needed to move that volume),
- JC-1 is not a 1:1 surrogate for the mine,
- Wells are hardly ever completed in such a manner that surface water does not leak into them from above, and therefore one cannot assume that 100% of the tritium measured in JC-1 is coming from the aquifer,

- The inputs to the CRAflush model were not measured or calibrated, and
- No drawdown has been measured in wells completed in the Blackhawk Formation, while considerable drawdown was measured in wells completed in the Star Point Sandstone.

**VI.** In February 2003, PacifiCorp initiated a tracer dye study in Electric Lake to help determine whether water from the lake is flowing into and being discharged from the Skyline Mine. A very minor amount of Eocene and Fluorescein dye were used at the time. In April 2003, an additional 50 pounds of Eocene dye was placed along the Diagonal fault in the lake and 35 pounds of Fluorescein dye was placed along the Connelville fault in the lake. So far, Canyon Fuel Company indicates that no trace of either dye has been encountered in collection packets inside the mine, or the mine-water discharge; nor has their laboratory found any in collection packets located at the JC-1 well. However, they have noted numerous positive dye signatures downstream of the dam. PacifiCorp states that they found small traces of dye in 3 of 5 non-consecutive samples taken from JC-1 between May 29 and July 14, 2003 (Aley, 2005). Prior to the first dye hit, they had sampled 12 collection packets with no hits between February 27 and May 29, 2003. Though they continued sampling, they did not find any other hits after the July 7-July 14 packet. PacifiCorp added more dye to the lake in February 2004 (75 pounds of Fluorescein dye along the Diagonal Fault, and 125 pounds of Fluorescein dye along the Connelville Fault). They report small concentrations of the dye in 10 of 13 non-consecutive samples taken at JC-1 from December 28, 2004 to May 12, 2005. They also had hits in Huntington Creek below Dam 1, below Dam 2, above the Left Fork of the Huntington Confluence, and at Little Bear Campground. This study shows that there *may* be a connection between the lake and the mine, but the Division cannot fully accept the conclusions. Some of the Division's reservations about this report include:

- No attempt to quantify the flow, or develop a mass balance is made,
  - The Benchmark study, which is used to explain why no mass balance study can be done, used freshly crushed, dry rock, which would behave quite differently than saturated fractures,
  - Also in relation to the Benchmark Study, and their reasoning for not being able to conduct a mass balance analysis, Mr. Aley states on page 3 of appendix B that *"Unfortunately, neither I nor anyone else with whom I am familiar has a good suite of data on dye detection rates through a lake similar to Electric Lake. As a result, we are in the realm of opinions without a highly relevant data base to support the opinions"*, which indicates that a good baseline knowledge is lacking in regard to dye adsorption and travel-rates,
- During the early phase of the study (2003) the Ozark lab was sampling dye packets for both PacifiCorp and Canyon Fuel Company. Canyon Fuel has stated that they submitted the samples to the lab "blind" (labeled by number code, not as JC-1), and the lab indicated no hits for the same period of time that is now reported to have hits in 3 of 5 samples at JC-1. This is a serious concern, and
- This study and others attempt to use the JC-1 well as a 1:1 surrogate for the mine, which it is not since it is drilled into the fracture system 70 feet below the mine.



Though the majority of the water seems to be coming from the Star Point Sandstone (Canyon Fuel observations, age-dating data, and chemical composition studies), there seems to be a component of modern water (tritium studies) that *may* be coming from Electric Lake. The connection with Electric Lake, though a possibility, has not yet been shown in a manner that the Division can fully accept. In order to make such a conclusion, the Division's concerns with the various reports would have to be answered in a satisfactory manner.

Thus far, no one has attempted to provide a mass balance of where the Electric Lake losses are going – such a study would be of tremendous value. Also of great value would be to gauge what happens to the “lost” water quantity, the mine inflow rate, and the reservoir function during a test shut-down of JC-1 for a period of several months. PacifiCorp planned such a test, and shut down the JC-1 pump on September 15, 2005. Because of underground pumping problems and other in-mine concerns, Canyon Fuel asked PacifiCorp to turn the JC-1 pump back on just 15 days later (Sept. 30). Because the inflow sites are now inaccessible, it is unclear how much the inflow to the Skyline Mine increased with the JC-1 shutdown.

#### Subsidence

Especially where overburden is minimal or fracturing is extensive, there is potential for the capture of ground water or surface water by subsidence cracks (Engineering-Science, 1984; Valley Camp, 1993, Appendix R645-301-724.600). Subsidence impacts are largely related to extension and expansion of existing fracture systems and upward propagation of new fractures. Because vertical and lateral movement of ground water in the permit area appears to be largely controlled by fracture conduits, readjustment or realignment of the conduit system may potentially produce changes such as increased flow along fractures that are opened and diversion of flow along new fractures. Increased flow rates would potentially reduce residence time and improve water quality. Some of the perched, localized aquifers could be dewatered. Ground water diverted from seeps or springs fed by such systems would most likely emerge nearby at another surface location rather than drain down into the mine. Sealing of subsidence cracks by clays in the Blackhawk is expected to minimize long-term effects of subsidence on the hydrologic systems (see section 2.3 of the Skyline Mine MRP).

Mines are designed to restrict subsidence to the permit areas. Because the perched aquifers of the Blackhawk Formation are lenticular and localized, there is little potential for the effects from dewatering these aquifers to extend beyond the permit area. Where mining and subsidence occur within the saturated rocks of the regional aquifer there will be a large increase in permeability locally. With time, permeability will decrease as fractures close and the potentiometric surface will establish a new equilibrium. Residual impacts should be restricted to the previously mined area and will probably be negligible. The addition of the Winter Quarters / North Lease area has been a source of concern because portions of Winter Quarters and Woods Creeks are perennial in nature and support aquatic life. However, the combination of extensive overburden, the sealing and pliability of the overlying Blackhawk Formation (see section 2.3 of the Skyline Mine MRP), and the proposed mining of only one (1) coal seam drastically reduces the potential for any adverse impacts to occur due to subsidence.

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## **VIII. MATERIAL DAMAGE DETERMINATION**

### **Mine In-flows**

Most of the major inflow water encountered by mining at the Skyline Mine is most likely generated from the deeper Star Point Sandstone. Studies done to date have not been able to conclusively prove or disprove a connection to Electric Lake, though a percentage of the inflow is of modern origin. The deep Star Point Sandstone does not contribute directly to the water budget of the Mud Creek or Upper Huntington Creek basins. However, changes in the potentiometric surface in the Star Point Sandstone may influence recharge and movement of ground water through the overlying unsaturated zone. Because the potentiometric surface is expected to recover to approximate pre-mining conditions after mining ceases, the overlying unsaturated zone should also be expected to recover to approximate pre-mining conditions.

Current information suggests no adverse impacts are being observed in Eccles Creek/Mud Creek or Electric Lake due to the increased discharges of water. Monitoring of mine in-flows, groundwater, and surface water within the Mud Creek – Upper Huntington Creek basins is being conducted to adequately identify any future impacts. Information is continually being updated and re-assessed to evaluate any impacts.

### **Loss of Habitats for Cutthroat Trout and Invertebrates**

The critical spawning habitat for Yellowstone cutthroat trout in Burnout Creek is entirely within the Skyline permit area. Upper Huntington Creek and several of its tributaries are within the permit area, with the uppermost reaches of Huntington Creek extending upstream beyond the permit boundary. Large numbers of cutthroat trout have been seen in James Creek during spawning season, and it functions as a spawning stream when there is enough water for the fish to move through the culvert below the land bridge, or over the top of the land bridge. Lower Burnout Creek is a spawning stream, and Boulder Creek has been modified to facilitate access by spawning trout (installation of a fish ladder), but it has not been officially determined whether fish are now able to move upstream of the dam.

Subsidence could produce physical barriers or loss of water flow sufficient to block fish from reaching spawning areas. Sedimentation caused by subsidence or other mine related activities could bury gravels used for spawning. These effects would probably be mitigable by removal of barriers; restoration of flow, or sediment control and no material damage would result. A study done in Burnout Creek indicates that any impacts to the streams would be temporary and minimal. The study was conducted while mining two different seams under Burnout Creek for a number of years. Subsidence in the area was found to be on the order of 7 feet, and the DOGM/OSM Evaluation Team found no observable effects in 2005.

Cutthroat trout are found in Eccles Creek and other streams of the Mud Creek drainage. This trout population has been heavily decimated by sedimentation, eutrophication, or toxicity

several times in the past. These negative impacts generally have been caused by human activity in Eccles Canyon, namely road construction and coal mining. Beaver dams, which are natural traps for fine sediment, have interacted with the additional fine sediments produced by human activities to further reduce trout habitat in Eccles Creek. Trout populations have recovered when the impacting activities have ceased, been modified, or otherwise mitigated, although recovery has not been determined to be 100%.

No material damage to habitats for trout or invertebrates is anticipated for current or planned mining and reclamation, and monitoring is ongoing.

### **Increase or Decrease in Stream-flow**

There should be no noticeable change of flow in streams in the Huntington Creek drainage. In Electric Lake however, the JC-1 and JC-3 wells have a potential to provide roughly 46 percent of the total volume of the lake on an annual basis, should pumping continue. With the drought conditions experienced from 1999 thorough 2003 the added water is appreciated downstream. When the current drought conditions reverse, and if mine-water discharges continue, excessive flows entering the lower Huntington drainage could potentially cause erosional impacts to the stream channel.

The impacts of mine inflows being pumped to Eccles Creek are minimal to that stream. It's well armored and shows little sign of degradation. The impacts to Mud Creek have a potential to be greater than those to Eccles, but these are also minimal. As indicated previously, the potential negative impact to Mud Creek from the increased flows is not the interruption of agricultural activity but the acceleration of instability in the channel banks and increased erosion of the stream channel in reaches of the channel that are not well vegetated. The area impacted would be very small in relation to the acreage being pastured and would be negligible to the total production of the pastures. Both streams are being monitored continuously and possible impacts should be detected.

At the cessation of mining, flows in Eccles Creek should return to pre-mining levels because mine discharges will cease. Though the mine will most likely fill with water, no gravity discharge is expected because the natural potentiometric surface is much lower than the mine portals. Less flow during drought periods would be the most noticeable of the possible effects. There is no present or foreseen material damage resulting from changes in flow due to present or projected discharge from the mines.

### **Water Quality**

Historically, sulfate and TDS have increased in Eccles and Mud Creeks as a direct result of mining activities. UPDES limits were exceeded for a time at the Skyline sedimentation pond. The suspected source of the problem, gypsum used for dust control, was eliminated and water quality began to recover.

Prior to the 2001 inflows, Whisky Creek contributed approximately 6 percent of the flow in Eccles Creek and 2 percent of Mud Creek, respectively. Because it is such a small percentage of total flows, and the channel has been restored, Whisky Creek will have a minimal impact on the water quality within the Mud Creek basin.

In the late 80's and early 90's excessive nitrogen and phosphorous compounds were introduced into Eccles Creek by mining activities. Sewage was suspected as the source of the contamination at one time, but emulsified oil from longwall hydraulic systems and detergents were determined to be the sources. Fish and invertebrate populations were greatly reduced or eliminated from much of the stream, either because of avoidance or toxicity. Populations recovered after the causes of the contamination were eliminated. The possibility that excessive nitrogen and phosphorous nutrients in inflowing streams could lead to eutrophication of Scofield Reservoir is a possible concern, but has not been an issue since the emulsified oil and detergents were changed.

The increased flows in Eccles and Mud Creeks, resulting from the pumping from the Skyline Mine, may have had a beneficial impact by diluting normal in-stream levels of dissolved solids with lower-TDS water. The impacts on sedimentation and nutrient loading in Scofield Reservoir have not been fully determined. However, in the short term, the increased flow has been beneficial in maintaining water above the dead-storage level during the recent four years of drought.

Water quality problems have so far proven to be mitigable. No material damage to water quality is expected, but water quality must continue to be monitored diligently to avoid even short-term problems.

The quality of water entering Electric Lake will be closely monitored both at the discharge and within the lake, to ensure that no degradation of water occurs.

### **Erosion and Sedimentation**

Fine sediments in Eccles Creek have increased as a result of road construction and coal mining related activities. Coal fines are a notable addition to the fine sediment load. One impact of the increase in fine sediment has been reduced trout and invertebrate populations because of suffocation of trout eggs and fry, burial of gravel used for trout spawning, and loss of suitable invertebrate habitats.

Reconstruction of Upper Whisky Creek and reclamation of the area of the White Oak Mine that was surface mined was completed in late 2005. Fine sediments and runoff associated with that work were mitigated by having all flows report to sedimentation ponds until surface roughening and seeding of all areas was complete. Native stream channel sediments in Upper Whisky Creek were removed and stockpiled for later reconstruction of the channel. Long-term effects to the Mud Creek drainage system should be minimal.

A long-term concern is the loss of water storage capacity in Scofield Reservoir from sedimentation. In the past, sediment traps have been suggested as a means of removing the fine sediments originating in the Eccles Creek drainage. The increased flow in Eccles and Mud Creeks, resulting from the pumping from the Skyline Mine, may have had a beneficial impact by flushing more fine sediment from these streams. The impacts to sedimentation in Scofield Reservoir have not been determined yet.

Sedimentation has not been a problem in the Huntington Creek drainage. To ensure the discharge of the JC wells did not scour the lake bottom and create a suspended solids problem, PacifiCorp supplied extensive armoring of the lake bottom at the point where the discharge enters the lake. Photos 1 through 3 illustrate the armoring of the lake bottom and the channel constructed to carry the discharge water from the pipe to the Huntington Creek channel.

Material damage from erosion or sedimentation is not anticipated in either Mud Creek or Huntington Creek, but monitoring is ongoing and will continue until mining and reclamation are complete.

## **IX. STATEMENT OF FINDINGS**

No evidence of material damage from the actual mining operations has been found. No probability of material damage from actual or anticipated mining operations has been found. The actual and proposed coal mining and reclamation operations have been designed to prevent material damage to the hydrologic balance outside the permit areas.

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**STATEMENT OF FINDINGS**

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## Appendix A

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<b>Figure 15</b>	Electric Lake vs. SWSI



**APPENDIX B**

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## **Appendix B**

**Photo 1**

**Photo 2**

**Photo 3**

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